DOCUMENT RESUME

ED 151 148	SE 023 095
AUTHOR	Caldwell, Lynton K.; Siddiqi, Toufiq A.
TITLE	Science, Technology, and Public Policy. A Guide to Advanced Study.
INSTITUTION	Indiana Univ., Bloomington. School of Public and Environmental Affairs.
SPONS AGENCY	National Science Foundation, Washington, D.C.
PUB DATE	Apr 72
NOTE	487p.; For related documents, see SE 023 093-094 and ED 045 366
EDRS PRICE	MF-$1.00 HC-$26.11 Plus Postage.
DESCRIPTORS	Bibliographies; Curriculum Guides; Policy Formation; *Public Policy; Science Education; *Sciences; Social Development; Study Guides; *Teaching Guides; *Technology

ABSTRACT

Presented are study guides for selected aspects of public policy for science and technology, and their impact upon society and public affairs. Each guide includes a topic outline, bibliography, and leading questions. The topics include: (1) Science and Technology as Social Forces; (2) The Organization of Science and Technology; and (3) Policy Problems of Science and Technology. (SL)

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SED 70-03360

SCIENCE
TECHNOLOGY
AND PUBLIC POLICY

A GUIDE TO ADVANCED STUDY

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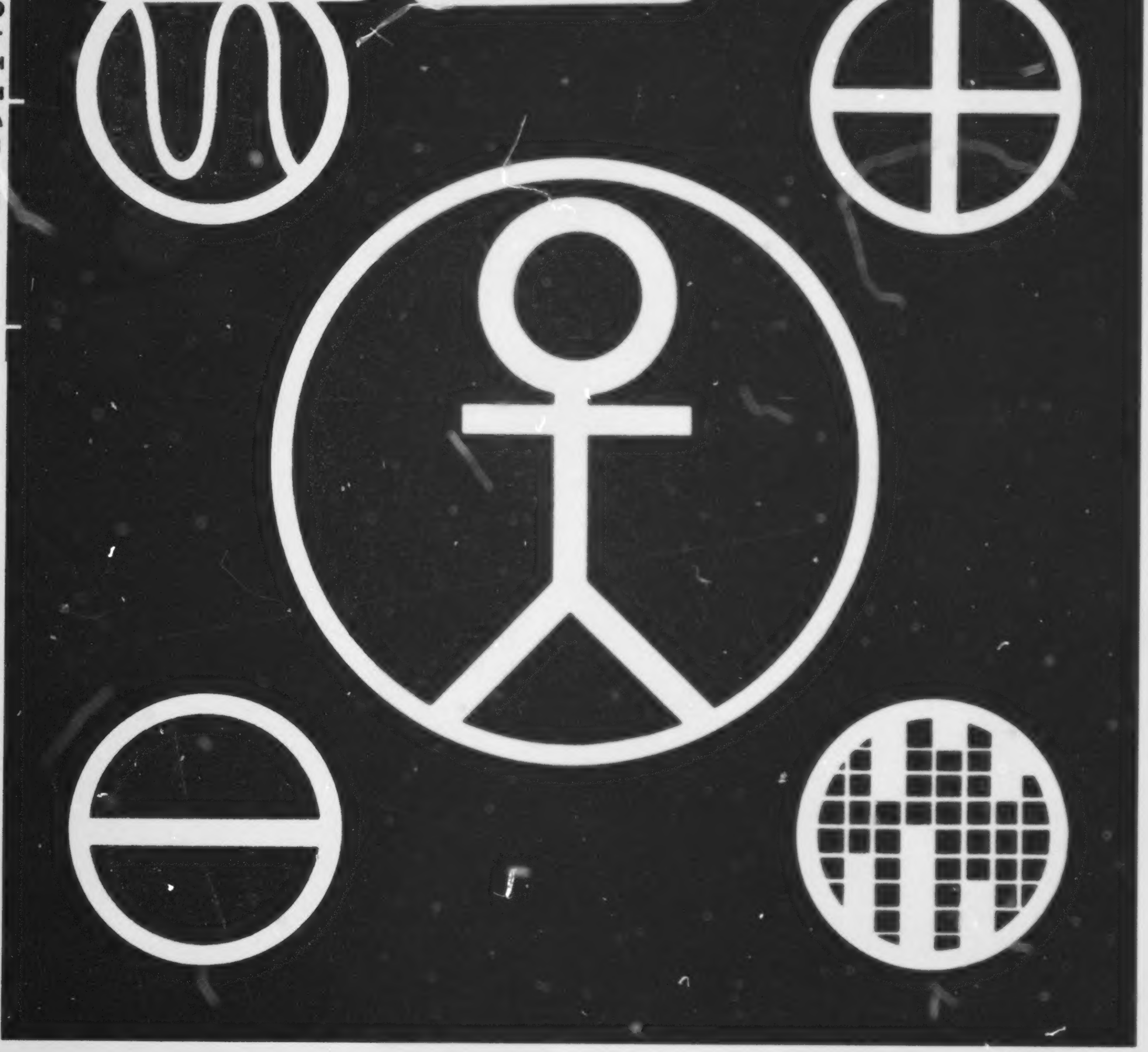

SCIENCE, TECHNOLOGY, AND PUBLIC POLICY
A GUIDE TO ADVANCED STUDY

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With the Assistance of
A Grant from the National
Science Foundation

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Bloomington, Indiana 47401

April, 1972

THE STUDY OF PUBLIC POLICY FOR SCIENCE AND TECHNOLOGY

A Preliminary Statement

1 The following outlines of topics, questions, and readings are intended as guides to the study of selected aspects of public policy for science and technology, and their impact upon society and public affairs. This material is organized as a course appropriate to graduate or upper-division undergraduate instruction. Its scope is comprehensive and implies a high level of generality if the course were offered in a two-semester or three-quarter academic year. But each of the fifteen main topics into which the subject matter has been divided may be studied in depth and detail, and contains sufficient material for intensive study where desired.

2 The study guide was developed over a two year period, with assistance from the National Science Foundation, and has been revised following three years of experience. The course of study which it represents initially was experimental, the field of study being relatively new to universities in America or abroad. Outlines of similar or related courses offered in other universities were examined, not necessarily for the purpose of borrowing from or improving upon them, but rather to see how other institutions were dealing with the instructional problems of the field. If there is a one best way to study public policy for science and technology, the authors and revisers of this study guide have not found it. There are many approaches to the field of study. The advantages of some over others appear to depend in large measure upon the character of the institutions offering the instruction and upon the needs and backgrounds of the students.

3 The objective has therefore been to develop this study guide as a basic instructional facility rather than as a model course. The fifteen topics are, in effect, building blocks and can be put together in many different combinations. Individual topics can be taken apart and recombined, the keyed references providing reading lists for the new combinations. The study guide is easily adaptable to self-instruction; the topical abstracts, outlines, questions, and keyed references enable the student to follow a systematic course of learning without the direct assistance of textbooks or instructors.

4 An outgrowth of this development in curriculum construction has been a selective but comprehensive annotated bibliography in Science, Technology, and Public Policy prepared under a contract with the National Science Foundation. This three-volume compilation of references, distributed by the Foundation, covers material published in English between and including the years 1945 and 1970. Its use can assist further specialization in the field of study.

5 The field and focus of the study of public policy for science and technology have often been misconstrued. Students in this field are concerned primarily with public policy and secondarily with the subject matter of science and technology. They must, to the extent of their interest, become students of social or political science even though their prior training may have been in some other academic field. The study of public policy for science and technology is not intended as an answer to the need for an enlarged and improved public understanding of the substance and methods of the sciences. Efforts to bring understanding of science to college undergraduates or to citizens generally could contribute to better public policy for science and technology. But this task involves a different subject matter and focus and, ideally should be undertaken by the scientists themselves where the subject matter of their own disciplines is taught. In the field of policy studies the scientists are social scientists, although the assistance of professionals in the physical and biological sciences, medicine, and engineering is also required. As this volume indicates, scientists have been extensively involved in the shaping and criticism of science policy and in the application of science and technology. Scientists do, therefore, contribute to the study of public policy for science and technology even though relatively few of them may ever become actively involved in it as teachers or researchers.

6 One may concede that the process through which public policy is formulated and applied is an appropriate focus for study and yet question whether there is anything so distinctive about public policy for science and technology as to warrant special attention. It might be argued that the policy process may be studied by political scientists, but that study of the substance of policy belongs to the discipline primarily concerned with the subject matter of policy. For example, this reasoning would leave the study of the substance of weather modification to meteorologists, and of water pollution control largely to chemists. There can be no objection to this approach, provided that the natural scientist is willing to become a student of the social and political implications of his discipline. But the highly specialized character of modern science makes this interdisciplinary approach difficult.

7 Understanding of the problems of public policy in any substantive field requires a synthesis of knowledge of both the substance and processes of policy. This synthesis can be achieved in several ways. It is possible to achieve it largely because there is available to the student extensive policy-oriented writings by scientists themselves and by nonscientists well-grounded in the scientific aspects of policy issues. Synthesis may further result from the various forms of intellectual interchange between students of the processes of public policy-making and administration, and students of the social implications of science and technology.

8 The intrinsic importance of science and technology as subjects for policy studies depends upon their significance in the shaping of human societies. The tremendous impact of science and scientific technology on the modern world is now generally recognized. But, until recently, the effects have been widely assumed to be beneficial and to require no special attention. Since 1945, however, the hitherto small stream of critical comment on the uses and effects of science and technology has swollen to Amazonian proportions. Science and technology have become major topics for policy consideration in all industrial societies, in all modern governments, and in international affairs. Dangers of the overuse, underuse, and misuse of science are becoming matters of public concern. And at long last, the universities have begun to recognize their own responsibilities not only for advancing understanding of science itself, but also for advancing public understanding of its impact upon society. It is not easy to fit the study of public policy for science and technology into the conventional disciplinary structure of universities. But the great importance of the issues with which this aspect of policy study is concerned gives hope that this task, which implies new relationships among the disciplines, will somehow be accomplished.

A NOTE ON THE REVISED VOLUME

1 Following the printing of 500 copies of Volume I of Science, Technology, and Public Policy in 1968, requests for copies rapidly reduced the supply. Approximately 250 copies were distributed from Indiana University to colleges and universities, government agencies, and individuals teaching or organizing courses in science, technology, and public policy. An additional 100 copies were distributed by the National Science Foundation, and the balance were used at Indiana University and Purdue University for instructional purposes. Within two years, the Volume was out of print, except for a small supply for classroom use.

2 Three years' experience with Volume I suggested the following changes in its organization and content. A new Topic 13, Technological Forecasting and Assessment, has been added, and former Topics 09, International Technoscientific Organization, and 12, International Technoscientific Cooperation, have been combined under the latter heading. The fifteen topics are now equally divided among the three principal sections. Bibliographical material has been almost doubled, and the selections for basic readings have been extensively revised. The wording of the title has been revised; study guide being substituted for syllabus, as more descriptive of the Volume. This volume is a revision and expansion of the first of a two volume syllabus on Science, Technology and Public Policy prepared with the assistance of a grant from the National Science Foundation. This publication, in its revised form, will appear as two separate but related study guides with the volume numbers dropped. The original Volumes I and II were published by the Department of Political Science at Indiana University.

3 The authors gratefully acknowledge the helpful suggestions of users in the revision of this work. Appreciation is also expressed to the National Science Foundation for a grant of funds to assist revision and reprinting. The authors also express their gratitude to Hal Kibbey, Jan Lundy, May Lee, Mary Celenko, and staff of the Indiana University Libraries and the Indiana University Printing Plant for their assistance in the project.

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I

SCIENCE AND TECHNOLOGY AS SOCIAL FORCES

The five topics of this section introduce the student to the study of the effects of science and technology in modern society and afford background for the remainder of the course. It is hardly feasible to consider public policy for science and technology without some knowledge of what the terms "science" and "technology" mean, how they are related, and how they are different. This defining or clarifying of concepts is the substance of Topic 01. Science is explored in Topic 02 as an historical aspect of Western culture that has evolved into an autonomous universal culture of its own. Topic 03 is concerned with the ways in which science and science-based technology reshape traditional culture and give rise to problems that society attempts to solve by bringing science and technology under some form of public control, and by reshaping domestic, economic, educational, and legal institutions to conform to the impact of science and technology. Topic 04 describes science as an occupation, examines the characteristics of science-based fields, such as engineering and medicine, and analyzes the way in which scientific skills are utilized for technological purposes. Topic 05 outlines the impact of science on general education and on the preparation of scientific workers, and considers means to enlarge the public understanding of science. The concept "public policy" is not analyzed in this section. It may be sufficient to state here that public policy in the context of this syllabus means the choices that the public really makes through the action or inaction of government. Public policy as used in these topics is what government does, not necessarily what the law is presumed to imply, or what presidents, legislators, or citizens generally assert to be public policy. Public policy is therefore an imprecise concept and must receive a more rigorous and penetrating analysis before it can be given a clearer definition.

TOPIC 01 THE MEANINGS OF SCIENCE AND TECHNOLOGY

This topic provides an examination of science as an intellectual and social endeavor. Science changes man's view of reality and enlarges his ability to cope with this reality through technology. It thus becomes a social force capable of permeating all aspects of human life. Social institutions and formalized expressions of human experience in religion, art, philosophy, and law, have been unsettled, modified, and sometimes destroyed by force of scientific knowledge. Science as a way of thinking and of perceiving is therefore a continuing challenge to established beliefs, traditions, and authorities. It affects the conceptual and institutional bases of society and government, and inevitably becomes a factor in politics, notably in the shaping of public law and administration.

Although technology is as old as the arts of tool-making, ritual, and warfare, it has now become the major means for transferring scientific thought into social action. But technology is not merely a vehicle for science-based innovation; it is also a powerful force for the advancement of science. Instrumentation and refined research techniques are essential to the development of modern science. Radio telescopes, electron microscopes, and gas chromatography illustrate the dependence of advances in science upon advances in technology. Although separable in principle, science and technology in the more advanced industrial societies of the modern world are merged into a technoscientific complex of unprecedented power. Control of the transforming power of science-based technology thus becomes the object of competition among groups and individuals representing differing interests, values, and assumptions. The consequences of this political or policy-shaping competition are of great social importance, especially because of the destructive potential of technoscientific power and the need for organized social effort to maximize its beneficial effects.

The culture of advanced science and technology that is emerging in the late 20th century requires for its management widespread understanding of science and technology. Technoscientific society is structured by complex interdependent systems. Informed and intelligent cooperation is necessary to make these systems work. To direct and control the powers of science and technology it is necessary to understand their natures, requirements, and relationships. To manage these powers for human welfare also requires understanding of human needs and values. And so examination of the meanings of science and technology, and of the significance of these meanings for society is a logical point of departure for the study of public policy for science and technology.

TOPIC 01 THE MEANINGS OF SCIENCE AND TECHNOLOGY

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LEADING QUESTIONS

1. What is the meaning of "the scientific method"? What criteria are used, and by whom, to determine what methods are "scientific"?

2. Is advanced technology synonymous with "applied science" or are there differences between these terms? If differences, what are their implications?

3. What are some of the more important instances of the dependence of "pure" science upon technological innovation? (For example, in astronomy, physics, neurology, and microbiology.)

4. Do you agree that the interaction between science and technology is more the exception than the rule, and that the achievements of the last two centuries owe more to the advance of technology than to the progress of science?

5. Under present and prospective conditions of societies with highly developed technology, is there justification or utility in an intellectual attitude that separates scientific discovery from technological application? Should the two processes be viewed as a single continuum, or as interacting variables?

6. What is meant by the "science of science"; by the "sociology of science"; by the "political science of science"? How do they differ from the study of the "history and philosophy of science"? How does each of these fields differ from the study of "science, technology, and public policy"?

7. If you could reorganize a university upon the basis of the present state of knowledge would you change the present formal organization of the sciences and technical studies? If so, upon what basis or criteria would you act?

8. What are some of the more common popular misconceptions of science and technology? Why may these misconceptions prove to be socially harmful?

9. Is the "mystique of science" solely a consequence of unsophisticated popular attitudes? Has it been cultivated or resisted by scientists?

10. Stephen Toulmin writes: "Our lives are changed by its (science's) handiwork, but the population of the West is as far from understanding the nature of the strange power as a remote peasant of the Middle Ages may have been from understanding the theology of Thomas Aquinas." Do you agree?

TOPIC 02 SCIENCE AS AN ASPECT OF MODERN CULTURE

Every major aspect of modern culture or technology has been influenced by science; the perceptions, assumptions, themes, and techniques of the arts and humanities have been profoundly affected. Science may be said to have created a universal culture of its own--the technoscientific superculture--which overlays traditional societies and to which individuals, regardless of particular nationality, may equally belong as common members.

There is, nevertheless, in all modern nations a substratum of pre-scientific and unscientific attitude and belief that greatly complicates the shaping of public policy for science and technology. Nonscientific attitudes tend to be strongest in domestic, political, and religious affairs. Where strongly held, nonscientific values conflict with scientific judgment (as with family planning and population control), the task of public policy formulation is complicated.

Unlike traditional cultures, that may relate to all aspects of an individual's existence, the technoscientific superculture is incomplete. There are many aspects of life to which science and technology contribute only indirectly or not at all. No person can live wholly in the technoscientific superculture. The greater number of people in the world as yet live almost wholly in traditional or at least in nonscientific cultures. But persons who belong to the superculture of science and technology live in two cultures--the one in which they were born and reared, and the one in which they work as scientists, engineers, or physicians, with attitudes and techniques shaped through advanced technoscientific education. Where these two cultures are inconsistent with one another and are contradictory, conflict between and within groups and individuals arises. A notable instance of this conflict has been described by C. P. Snow in *The Two Cultures*.

Although it is possible to distinguish technoscientific culture from traditional culture, they are not manifest as clear-cut distinctions in most individuals. In any individual there may be a complex mixture of traditional attitudes and behavior patterns with beliefs and methods attributable to science. Modern science is, indeed, an outgrowth of historical Western civilization and in one sense is more truly an advanced phase of this traditional culture than an alien overlay. In this advance, however, the ties of modern science to historical Western culture have become increasingly attenuated, and in non-Western societies to which it is alien, science has often been a disruptive force. The wise use of science and its reconciliation with elements of traditional culture have now become challenges to the integrity of all human societies. Thus public policy for science is linked to social policy generally, and requires a high level of synthesis in conceptualizing, and planning for society's future.

TOPIC 02 SCIENCE AS AN ASPECT OF MODERN CULTURE

Selected Basic Readings:

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TOPICAL OUTLINE	REFERENCE KEY
I. Science as an Aspect of Western Civilization	59, 83
A. Historical and philosophical roots of modern science in ancient Greece and Rome	
Scientific thought a distinguishing characteristic of Western civilization?	28, 43, 67, 98
1. "Scientific" epistemology: a dual process of arriving at and judging knowledge. Application of such criteria, e.g., by Artistotle, to the totality of human knowledge	21, 84
2. The concept of action, by the individual or the society, as ruled by reason, i.e., denial of tradition or authority as the necessary guides to action. Consequences in ethics, law, science, and technology	82, 85, 86
3. The concept of man and the universe as "transparent" to the knowledge-seeker--epistemological optimism versus epistemological pessimism	48, 96
4. Concepts of the value of knowledge for its own sake	74
B. Development of intimate connections between science and technology (Review concepts developed in Topic 01)	38, 42
1. Ancient and oriental views	
a. Little or no connection between science and technology	28
b. Early links of scientific thought with religion, mysticism, medicine	87, 88
2. Three current views	
a. Classical: emphasizes the pursuit of knowledge for its intellectual and entertainment values. The "pure science" argument: science can progress best by following its own inner directions	1

b. Practical, or Baconian: while admitting its intellectual values, science can be methodically directed toward goals having social value, toward technology	52
c. Technological: science is or should be related to the unfolding of technological evolution which, in the long run, is self-augmenting; the direction of scientific progress is shaped by technological as well as by historical and economic forces	67
3. Contrast and change: importation of modern concepts of science, via technology, into semi- or non-Western cultures (See Topics 07, 09, 10)	4, 40, 44
II. Pervasive Influences of Scientific Concepts on Man's Images of Himself and the World (See also Topics 03, 16, and 30)	27, 58
A. The increasing status of "scientific knowledge" in a technoscientific culture, as contrasted with mysticism, revelation, and conventional wisdom	3, 10, 23
1. Historical relationships to the diminishing hold of traditional philosophical and religious beliefs	47, 72
a. The destruction of the comprehensive Aristotelian system by such influences as the new astronomy of Copernicus and Galileo	9, 88
b. Beginning of the age of epistemological optimism seen in the work of Descartes, Newton, and others--reaching its height in the 19th century	13, 47, 73
c. The new geology of Lyell and the evolutionary biology of Darwin placed the history of life on earth, and man himself, in new perspectives	17, 76, 77
2. Extensions (sometimes naive) of scientific concepts into other areas of thought (See also Topics 16, 21, 29, and 30)	16, 23, 50, 51, 66

a. The Copernican Revolution: a cosmological about-face	9
b. Darwin's Theory of Evolution: man's place in nature; social Darwinism	19
c. Pavlov's psychology: "brainwashing"; the control of society; concepts of human nature	
d. The new physics deriving from Einstein's relativity, Planck's quantum theory, Heisenberg's uncertainty theory: attempts to extrapolate to the social sciences and the humanities	32, 37
B. Identification of "modernity" with scientific and science-derived progress	66
1. Impingement of scientific and science-derived concepts on the Western world-view	17, 23, 54, 61
a. Development of the view of a historical, evolving, noncyclical world which is open to study by the methodology of science	
b. Growing identification of scientific thought as the model for all kinds of investigation	6
2. Historical linkages of the concepts of social and human progress with developing scientific thought (See Topic 25)	24, 30, 31, 66, 73, 96
a. The utopian literature of progress typified by the writings of Bacon, Owen, and Wells relied heavily on the rationality of science and on the fruits of science-based technology	58
b. The literature of the Enlightenment, which greatly influenced future developments in political structures, ethics, and religion, made appeals to scientific rationality and independence of thought	
c. Numerous socioeconomic theories, e.g., Cameralism, Technocracy, Marxism, have relied on technoscientific ingredients in the social systems proposed	64, 65, 67

3. Factors aiding in the reinforcement of the connection of scientific with social progress — 46, 65, 86, 88
    a. Continuing success of the scientific method as a tool for increasing knowledge of the physical world
    b. The demonstrated power of science as a generator of technology
    c. The power of science-derived technology as an agent of social change (See Topic 03) — 29,34

III. Emergence of a Universal Technoscientific Culture — 8, 57, 65, 72, 80, 90

A. Cultural self-consciousness and cultural conflict in modern society — 3, 5
1. Science and technology create awareness of cultural differences and cultural relativism — 17
2. Culture becomes a tool of politics, e.g., German Kulturkampf, Pan-Slavism, Americanism — 75

B. Emergence of a distinctively technoscientific aspect or "layer" of Western culture, 1860-1960 — 9, 25, 52, 79, 85
1. Growth of technoscientific occupations
2. Increasing prominence of science in universities, displacing classics, humanities, and theology — 20, 66
3. Transmission of technoscientific culture to non-Western world, via religious missionaries, business enterprise, military action, and philanthropic, educational, and technical assistance — 4, 43, 44
4. Growth of an international technoscientific intelligentsia, partially detached from traditional cultures — 5

C. The "Two Cultures" conflict (See also Topic 05)	14, 55, 60, 63, 91, 92
1. C.P. Snow's thesis--the English aspect of the general issue	18, 49, 56, 71
2. Extent of separability of scientific from Western culture	3, 5, 37, 62, 90
3. The complementary aspects of science and the humanities	9, 11, 22, 95
4. Bridging the "scientist-humanist gap"	12, 27, 41
5. Is a "third" culture really feasible?	2, 39, 61
a. Would its base be traditional or scientific?	
b. To what extent do we have evidence of the ability of existing traditional cultures to find an accomodation with science?	53, 66, 70, 73
6. Is a single universal culture the possible outcome of technoscientific influence? Would such a culture be beneficial, harmful, preventable, or self-renewable? (See Topics 20, 25, and 30)	35, 36

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LEADING QUESTIONS

1. George Sarton once observed that the proper focus of history should be on the development of science and technology, rather than on diplomatic relations and wars between nations. To what extent was his view valid?

2. What is the "fit" of science in modern Western culture? Is it indeed an integral part of this culture? Has its relationship to traditional culture changed?

3. Can we explain some of the characteristic differences between past and present Western cultures as consequences of the roles played in the culture by science? If so, could we extend this analysis to other cultures?

4. What explanations have been advanced for the growth of scientific thought in the West, in contrast to its delayed or arrested development in China, India, the Islamic world, and Africa?

5. You may recall a conviction--common a few years ago--that science can only develop in a "free" society. How would you evaluate this view? What kinds of societies do you think would be favorable or unfavorable to science?

6. Jacques Barzun argues that science has taken up a role in this culture analogous in many ways to that of religion in medieval times. Does this analogy seem reasonable? In what ways might it be misleading?

7. Is there evidence that the amount of superstition in society (beliefs in things that are not so) has remained relatively constant throughout historic time, and that science has merely changed the things about which people are superstitious? Would the G.N.P. as indicator of economic health be a superstition?

8. Do the following statements illustrate "scientism"? (a) science is the likely source of technological answers to all the problems of society; (b) science is the model for all types of investigation or problem-solving. Are these views reasonable, or should they be qualified or denied?

9. Science in the abstract has sometimes been described as anti-cultural. Why? How does this view of science relate to the "two cultures" controversy?

10. What significance do the following terms have in relation to science?
    a. Planned Parenthood
    b. Psychoanalysis
    c. Relativism
    d. Technocracy
    e. Human Engineering
    f. Christian Science

TOPIC 03 SOCIAL IMPACT OF SCIENCE AND TECHNOLOGY

Until the 19th century, the impact of science on society was largely distinguishable from the impact of technology. Since prehistoric time, technology rather than science has shaped man's behavior and his institutions. Technological innovation, as illustrated by such events as the beginning of agriculture, the discovery of the wheel, and the working of metals, has repeatedly revolutionized social conditions. But throughout most of historic time the influence of science has been confined to the beliefs of small numbers of highly literate or inquisitive individuals, and its effects have been slow and accumulative.

During the latter half of the 19th century, scientific discovery and technological innovation increasingly became interdependent. Since 1900, it has become difficult to distinguish precisely between scientific and technological forces for social change. The revolutionary developments of the present era, in atomic energy, in communications, in medicine, in automation, are technoscientific. They are applications of advanced scientific thought and sophisticated technologies. Although their impact upon society may or may not be as decisive as those earliest technological innovations that enabled man to pass from prehistory into historic times, their combined power to change institutions, beliefs, and practices is very great.

In the technoscientific society of the 20th century, technology appears to dominate science. Explanation lies in the direct applicability of technology to practical affairs. Technology directly serves economic, military, and civic purposes. Science informs the mind, but usually must be translated into technology before it can change the external characteristics of society.

The influence of technology on society has been the subject of an extensive and critical literature. A major theme is the automatic and self-augmenting character of technology; dealt with most explicitly in The Technological Society by the French sociologist, Jacques Ellul. The inevitability of technological development under favorable conditions is widely accepted and vigorously disputed. The issue is the extent to which societies of men can control and direct their scientific and technological development. A strong trend toward technoscientific determinism characterizes contemporary thinking and is especially prominent in technological forecasting and in science fiction.

But reaction against the doctrine of technoscientific inevitability has been growing, especially in advanced industrial societies. In its more constructive phase this movement is toward a more selective use of science and technology to shape a desired future instead of acquiescing in a future shaped by their uncritical applications.

TOPIC 03 SOCIAL IMPACT OF SCIENCE AND TECHNOLOGY

Selected Basic Readings:

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TOPICAL OUTLINE	REFERENCE KEY
I. Distinctions between the Effects of Science and Technology, and Their Significance	16, 173, 182
A. Common effects	8
1. Initial effects not necessarily same as ultimate effects	99, 182
a. Darwinian evolution	
b. Internal combustion engine	
c. Antibiotics in tropical countries	
d. Outer-space exploration	134, 178
2. Individual effects not always predictive of synergistic effects	16, 139
3. Technoscientific innovations frequently incur unforeseen effects owing to:	23, 44, 78, 138, 139
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b. Lack of adequate testing and analysis of possible consequences (Cf. Topic 13)	
4. Influence of science and technology may be changed as readily by emergent forces in the environment (e. g., competing forces, theories, or technologies) as by intrinsic properties of scientific ideas or techniques themselves	173
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2. Physical means for communication increase, but specialization complicates mutual understanding	53, 149, 159
3. Acceleration of the growth of knowledge:	169, 183
a. Increases obsolescence of knowledge and skill	
b. Enlarges the frontiers of ignorance	
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5. Through government and research, means are sought to cope with the social instabilities induced by technoscientific change	
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4. Feeling that the benefits of science and and technology have not been commensurate with the vast sums spent on them in the last two decades	98, 130

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LEADING QUESTIONS

1. Must a "technological society" emerge from the uncontrolled advance of technology? Are there factors common to modern industrialism, collectivism, democratic centralism, and utilitarianism that result primarily from the influence of technology?

2. "Technique," says Jacques Ellul, "is opposed to nature...technique as art is the creation of an artificial system." Is this an invincible thesis? Are there other interpretations of comparable validity?

3. What factors determine the course of technological innovation? Why are some technological possibilities neglected and why have some been suppressed?

4. What is meant by "technocracy"? Who are its prophets? What are its promises? What are its prospects? Who are the "technocrats"?

5. Do you think that the current disenchantment with science and technology is a temporary phenomenon, or does it represent a fundamental change in outlook? What could be the consequences for society of such a change?

6. Is "imbalance" a meaningful concept in relation to science and technology? What would be the criteria for ascertaining a proper balance?

7. What are the principal social trends induced by science-based technology? What are the implications of these trends for higher education, for scientific research, and for human social organization?

8. Why do perceptive students of technology (e.g., John Diebold, Cybernetica, VIII, 150-1[illegible]; or Robert Boguslaw, The New Utopians) urge the need for social innovation to match the pace of technological innovation? If Ellul is correct in asserting that technology shapes society, is it feasible to seek a non-technological countervailing force?

9. Is it possible to introduce technical change without destroying cherished beliefs and patterns of life?

10. Is deliberate and considered control over the direction of scientific and technological growth possible or desirable? What would be the principal dangers? What would be the necessary conditions for effective social control? For control that is also socially beneficial?

TOPIC 04 SCIENTIFIC WORK IN TECHNOLOGICAL SOCIETIES

In technological societies, work is increasingly planned and directed by persons with special competence in science or technology. In these societies growing numbers of people are employed in scientific and technical activities and a large number of new science-related occupations have arisen.

It is difficult to describe scientific work by classifying the workers. Distinctions among the several types of scientific workers are as much cultural as functional. Historical usage has differed among countries, so that we cannot use the English word "scientist", or its nearest counterparts in other languages, to classify a group of scientific workers that informed people everywhere would recognize as an identical occupational grouping. For example, the Russian nearest equivalent to the word "scientist" is applied to a wide range of scholars, engineers, and advanced biomedical and technical personnel who are not customarily classified as scientists in the United States or Western Europe. The American tendency has been to restrict the designation "scientist" to the physical sciences and to those fields of biology most closely related to physics and chemistry. With the possible exception of physical anthropology, which uses exact measurements, social and behavioral science professionals are classed as scientists only in a qualified sense. But regardless of designation, the knowledge and competence of technoscientific manpower has now become a major economic resource for national governments. In modern national states, public expenditures for education and training in science and technology are increasingly viewed as public investments. In the technoscientific superculture, wealth and power are inseparable from knowledge and performance effectiveness.

From its very beginnings modern science has been an enterprise of associations as well as of individuals. Scientific and technical work is today highly organized, and finds means for professional communication in the thousands of scientific and technical journals, congresses, symposia, and proceedings of scholarly meetings. The dissemination, storage, and retrieval of scientific and technical information has become one of the most distinctive and essential tasks of modern society. Scientific work is increasingly carried on through institutions for research and development and through large-scale cooperative programs. For more detail on institutional aspects of science see Topics 09, 12, and 15.

As organized forces of information and respected opinion, the scientists and their related professional associates influence public policy for science and technology. Accustomed to evaluating evidence on a basis of demonstrable fact rather than on the basis of popular preference, they sometimes find themselves in conflict with political values. The proper role of scientists in the politics of modern societies has aroused special interest, for it seems certain that science will be involved in many ways with the politics of the future.

TOPIC 04 SCIENTIFIC WORK IN TECHNOLOGICAL SOCIETIES

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TOPIC 04 SCIENTIFIC WORK IN TECHNOLOGICAL SOCIETIES

TOPICAL OUTLINE	REFERENCE KEY
I. Scientific and Technical Manpower in Modern Society	38, 68, 251, 260, 277, 307
A. Growing number and importance of scientific and technical occupations	
1. Science-based technology supersedes art, craft, and tradition	
a. Industry, from the Industrial Revolution	
b. Warfare and defense	
c. Agriculture	
d. Transportation	
e. Consumer services and goods	
2. Increasing social and economic dependence on new and highly interdependent science-based technologies	
B. Scientific and technical manpower as "capital" assets	171, 200, 232, 264, 265
1. Increasing identification of science-derived technology as the basis of economic growth and "progress"	41, 125, 251, 281
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b. Incentive	5
c. Special educational provisions	20, 119, 164
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e. Women in scientific professions	145, 148, 169, 254
3. Unemployment among scientists and engineers caused by	38, 142, 191, 210, 268, 269
a. Cut-back in aerospace and defense-related research	
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c. "Over-qualification" for many jobs	

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3. Professional ethics	198, 272
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3. Education and training (Cf. Topic 05)	
4. Social-psychological specialization	
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A. Societies of Scientists and other Scholars--Prototypes:	273
1. Accademia Secretorum Natural--Naples, 1560	
2. Accademia dei Lincei--Rome, 1603	
3. Accademia del Cimento--Florence, 1651	
4. Royal Society--London, 1662	
5. Academie des Sciences--Paris, 1666	
6. Russian Academy of Sciences--St. Petersburg, 1724	
7. American Philosophical Society--1743	
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(1) American Astronomical Society	
(2) American Chemical Society	

- (3) American Physical Society
- (4) Geological Society of America

b. Biological

- (1) American Physiological Society
- (2) American Society for Microbiology
- (3) American Society of Zoologists
- (4) Ecological Society of America

c. Behavioral and social

- (1) American Anthropological Association
- (2) American Psychological Association
- (3) American Economic Association
- (4) American Political Science Association
- (5) American Sociological Association

d. Science-related technical and professional

- (1) American Association of Petroleum Geologists
- (2) American Forestry Association
- (3) American Medical Association
- (4) American Society of Civil Engineers
- (5) Institute of Electrical and Electronics Engineers

2. Federations of scientific societies
   - a. National--USA
     - (1) American Association for the Advancement of Science 14, 142, 146
     - (2) American Institute of Biological Sciences 47, 212
     - (3) American Institute of Physics 9, 109
     - (4) Engineers Joint Council
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     - (1) International Council of Scientific Unions 7, 21, 27, 292
     - (2) International Union for Conservation of Nature and Natural Resources 12, 245
     - (3) International Social Science Council
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   - a. National Academy of Science 43, 176
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A. Prototypes: *Journal des Savants*--Paris, 1665 *Philosophical Transactions of the Royal Society*--London, 1665	
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1. To disseminate information 2. To establish priority in research 3. To establish communication between workers in a particular specialty 4. Sometimes to relate specialties to larger fields of interest	
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2. Specialized publications (various levels), e.g., *Journal of the American Chemical Society*, *Analytic Chemistry*, *Chemical Reviews*, *Chemical and Engineering News*, *American Behavioral Scientist*, *Bioscience*, *Physical Review*	
3. Philosophical and historical, e.g., *Cybernetica*, *Isis*, *Minerva*, *Journal of the Philosophy of Science*, *Technology and Culture*, *Perspectives in Biology and Medicine*	

4. Public issues and policies in science, e.g., *Science and Public Affairs: Bulletin of the Atomic Scientists*, *Impact of Science on Society*, *Minerva*, *Environment*, *New Scientist and Science Journal*

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   2. Reports and investigations by professional scientific groups as individuals--including government documents, e.g., reports of panels of the President's Science Advisory Committee, National Academy of Sciences, and Congressional inquiries and hearings
   3. Abstracting and citation systems and services, e.g., Biological Abstracts, Chemical Abstracts, Current Contents, Nuclear Science Abstracts, Science Citation Index 49, 73, 140, 144, 225
   4. Monographs and systematic works
      a. Single-author works
      b. Multi-author works
      c. Textbooks
      d. Dissertations--published and unpublished
   5. Encyclopedic works, e.g., *Encyclopedia of the Social Sciences*, *Handbook of Physiology*
   6. Manufacturers' technical publications
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      b. Brochures and pamphlets

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LEADING QUESTIONS

1. Why is science as a profession sometimes compared to a priesthood? Is the analogy in any sense valid? What does it mean?

2. Are there discernible elements in scientific work that tend to cause scientists to react in predictable ways to social issues? For example, are there particular social attitudes or viewpoints associated with science or with particular sciences?

3. How do you explain recurrent surpluses and shortages among scientists and engineers? What policies would be required to avoid repetition of such occurrences?

4. What consequences follow from the naiveté of certain prestigious scientists regarding mass social behavior and a paralleling naivete in society generally regarding the character and capacities of scientists?

5. Why has the employment of scientists in government occasioned so much study and concern? What have been the principal complaints of the government scientist against his employers? Of public officials against some scientists?

6. What changes, if any, in the education of scientists and technicians would improve the quality of their contributions to science and to society? If changes are indicated, how might they most effectively be implemented?

7. If scientists who leave scientific work for administrative or advisory responsibilities are still considered "scientists," why are science-trained physicians and engineers not considered scientists, even when they are actively using scientific knowledge and methods?

8. How important is the problem of communication among the science occupations and between them and other occupational groups? What, if anything, can be done to alleviate the difficulties?

9. What problems has the information explosion caused in scientific and technical fields? What have been some of the remedies, actual and proposed?

10. What has been the role of scientists in the formation of national policy? Should their participation increase in the formation of goals and priorities? What contributions are scientists making to international policies for science and technology?

TOPIC 05 SCIENCE, TECHNOLOGY, AND HIGHER EDUCATION

Man's knowledge of reality is both personal and social. The growth of civilization is measured by the accumulation and organization of knowledge. Contemporary man may have no greater intellect than did the man of Cro-Magnon. But he possesses an accumulating and transmissible culture that extends his knowledge far beyond direct personal experience.

The organization of knowledge into academic disciplines, or bodies of information and method called sciences, is artificial. The sciences are convenient ways of structuring knowledge, but the structures are constantly under stress as the substance and significance of knowledge change. A major task of higher education in the technoscientific age is the reorganization of knowledge. Two contrasting processes characterize the expansion of scientific knowledge. The first is specialization. Sciences such as chemistry and microbiology have been subdivided into ever more specific fields of specialization. The second is synthesis. Hybrid sciences, such as biophysics and geochemistry, form new specialties out of fusions between previously established sciences. And broadly inclusive synthesizing sciences or scientific concepts, such as ecology or general systems theory, move toward the integration of scientific knowledge and the systematic structuring of the unity of science.

The expansion and specialization of scientific knowledge created difficulties in the education of scientific workers and of citizens generally. For example, how much understanding of traditional culture, or of nonscientific concepts and values, is it desirable for scientific workers to possess? Particularly in a self-governing society, is it enough for scientists to know science--or should they know more to be effective as citizens or as fully developed human beings? And in a technoscientific society what do citizens need to know about science and technology? Can the great powers inherent in technoscientific knowledge be effectively controlled or responsibly used in a society in which the mass of the people does not comprehend the nature and implications of science or technology?

By the latter half of the 17th century, the power of science and technology to serve the interests of the state had begun to be perceived in European governments. Official patronage of science and technology began with the establishment of academies and, in the 19th century, was expressed in the founding of advanced schools of technology (e.g., les Grandes Ecoles in France) and by public financial support for faculties, institutes, and laboratories for scientific training and research. By mid-20th century, education for science and technology had become a major commitment in all technoscientifically advanced societies and was promoted and assisted by international agencies.

TOPIC 05 SCIENCE, TECHNOLOGY, AND HIGHER EDUCATION

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LEADING QUESTIONS

1. What are the distinctions usually drawn between scientific and technical education? Are these distinctions valid? Can or should scientific and technical education be kept separate?

2. What has been the history of government support for education in science and for technology? In the U.S.A.? In other countries? What seems to be the explanation of these patterns of support?

3. In what ways have science and technology contributed to the organization and methods of higher education? Can you cite specific examples of scientific instrumentation, information handling, teaching methods, and tests and measurements?

4. Why has scientific and technical education come to be described as "the knowledge business"? What is the explanation of the growing relationship between advanced scientific and technical education and economic growth?

5. What changes in fundamental education would be necessary to produce a "Third Culture" society? What would be necessary to achieve these changes?

6. What evidence, if any, indicates impending changes in science education in the United States? What appears to be the nature and direction of the trends? To what extent is specific governmental action involved?

7. It has often been claimed that the importance given to research on the campuses has led to the neglect of teaching by faculty members. Do you think it would be in the interests of the students if faculty research were relegated to a secondary position?

8. If you were compiling a list of science experts to be consulted in the course of an archaeological "dig" in a city occupied more than 5,000 years ago, what specific fields of scientific expertise would be included?

9. Does application of scientific methods to the arts and humanities destroy their special character and value? E.g., has textual criticism undermined the scriptural basis of religion?

10. How would you answer the question posed by Kenneth Boulding: "Dare we take the social sciences seriously?"

II

THE ORGANIZATION OF SCIENCE AND TECHNOLOGY

The five topics in this section examine the way in which the technoscientific enterprise of modern society is put together. But because the context within which this section is placed is one of public policy (rather than of industrial or economic development, for example), its emphasis is upon the machinery of government-science relationships. In other contexts, the relationship of science and technology to manufacturing, commerce, or agriculture might be given comparable emphasis. Organization of technoscientific enterprise is best described where it has been most deliberately and elaborately developed. And as the Topics are designed to assist understanding of the problems and processes involved in public policy for science and technology, and not to describe all possible government-science relationships, attention has been focused on five major but contrasting national systems--those of the United States, the Soviet Union, the United Kingdom, France, and Western Germany. Several other national technoscientific systems might have been added, but their study would have contributed relatively less toward the objectives sought in this section. The structure of international scientific cooperation is described, and it is in this global context that the future of public policy for science and technology will inevitably, in large measure, be placed. A special aspect of the international character of science and technology is the concluding topic in this section--Technoscience in the Developing Countries.

TOPIC 06 SCIENCE AND GOVERNMENT: THE UNITED STATES

Salient characteristics of the organization of science in the United States have been (1) autonomy, (2) diversified foci of decision on public policy for science and technology, and (3) growing interrelationships with government and industry.

Extensive governmental involvement and leadership in public policy for science and technology dates from World War II. Although there had been a continuing sponsorship of science by the federal government since the administrations of Washington and Jefferson, the Congress and the states remained largely apathetic. The scientific activities of government in the United States were directed primarily toward practical ends such as aids to navigation, the exploration of the west, and the setting of scientific and technical standards.

During the Civil War, however, the federal government assumed a more positive posture toward applied science. In 1862 the first Morrill Act set aside public lands for the support of higher education in agriculture and mechanic arts. And in 1863 the National Academy of Sciences was established as an advisory body to the government. By 1884 the growth of scientific agencies had reached a point where their relationships and organization became the object of study by a joint commission of the Congress.

World War I brought about increased governmental concern for science and led to the establishment of the National Research Council. In agriculture, conservation, public health, and technical standards, government was already engaged in scientific work. The new field of aeronautics had been entered. By 1916 the general structure of science that was to prevail until World War II was complete.

World War II and its aftermath led to a major expansion of government's role in science. Nuclear energy and exploration of outer space brought totally new functions to government. Establishment of the National Science Foundation and expansion of the research support activities of the National Institutes of Health, in addition to large expenditures for defense-related research and development, made the United States government the major national force in science and technology. An advisory apparatus in the executive branch was created (President's Science Advisory Committee and Federal Council on Science and Technology) and new committees for scientific policy were created in the Congress. The Department of Science idea, proposed as early as 1885, was again considered, but not adopted. As a technoscientific society took shape in America there was growing public concern with the interrelationships between government, industry, and the universities, particularly in the allocation of funds for research and development and in public policy toward technological innovation.

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TOPIC 06 SCIENCE AND GOVERNMENT: THE UNITED STATES

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I. Science and Public Affairs in the 18th Century	153, 184, 193, 209, 210, 238, 251, 299
A. Science in the colonies and confederation	
1. Influence of European science	
2. American Philosophical Society, 1743 (Franklin and Rittenhouse)	
3. American Academy of Arts and Sciences, 1780	
B. Science under the federal constitution	
1. Federalist concepts of governmental encouragement for science and technology	
2. Jeffersonian animadversions and practical compromises	
II. Science and Government in the 19th Century	184, 192, 193, 196, 197, 218, 238, 244, 253, 271, 299
A. Exploration and mapping of the continent	
1. U.S. Military Academy and Corps of Engineers, 1802	
2. The Lewis and Clark Expedition, 1804-1806	
3. The Coast Survey, 1807	
4. Department of the Interior, 1849	
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b. Hatch Act of 1887--agricultural experiment stations	
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6. The Allison Commission and a proposed Department of Science, 1884-1886	
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4. National Advisory Committee for Aeronautics, 1915	
B. Science and technology in World War I	197
1. Naval Consulting Board, 1915	
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1. Hoover Committee on Recent Social Trends, 1929 (cf. Report of the Committee, 1932)	
2. National Institutes of Health, 1930	143, 148, 158, 171
3. Science Advisory Board, 1933	
4. National Resources Committee (cf. Research--A National Resource, 1937)	
D. Science and technology in World War II and post-war period	38, 51, 92, 115, 185, 190, 212
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2. Office of Naval Research	31, 122
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5. The Atomic Energy Commission, 1947	54, 80, 112, 116, 208, 211
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10. Marine and atmospheric sciences	4, 40, 107, 245, 267, 278, 280, 284, 287, 288, 304, 306, 307, 311

11. Federal research laboratories	60, 71, 104, 106, 305
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1. In connection with federal scientific and technical programs, e.g., via contract with DOD, NASA, AEC	36, 58, 77, 91, 96, 127, 141, 142, 208, 226, 277, 304
2. Through the science advisory structure, e.g., Office of Science and Technology, Federal Council for Science and Technology, President's Science Advisory Committee, National Aeronautics and Space Council, Council on Environmental Quality, National Academy of Sciences, National Academy of Engineering, Smithsonian Institution	1, 3, 16, 22, 28, 37, 48, 64, 73, 82, 121, 124, 134, 151, 152, 164, 285, 286, 290, 308, 309, 312
3. Through the administration of research grants, fellowships, and other assistance to scientific research and education, e.g., through the U.S. Public Health Service and National Institutes of Health, U.S. Office of Education, National Science Foundation	2, 35, 42, 46, 59, 90, 99, 118, 119, 137, 156, 163, 167, 170, 174, 177, 217, 222, 224, 288, 289
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C. Review and assessment of the status and direction of public policy and administration affecting science and technology	17, 34, 47, 45, 64, 66, 74, 88, 157, 166, 179, 182, 229, 276, 299, 313
1. The Congress of the United States, e.g., House of Representatives: Committee on Science and Astronautics; Committee on Agriculture; Committee on Armed Services; Committee on Interstate and Foreign Commerce; Senate: Committee on Aeronautical and Space Sciences; Committee on Agriculture and Forestry; Committee on Appropriations; Committee on Armed Services; Committee on Commerce; and Library of Congress, Science and Technology Division	5, 26, 29, 43, 52, 79, 85, 94, 132, 135, 165, 180, 181, 221, 291, 293, 295, 297, 298, 299, 302
2. Executive Committees or Commissions, e.g., Steelman and Bush reports, Environmental Pollution Panel of the President's Science Advisory Committee, National Council on Marine Resources and Engineering Development	124, 267, 285, 309, 312
3. Analysis and criticism of United States science policy structure (see also Topic 11)	1, 27, 45, 66, 101, 120, 160, 178
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b. Over-emphasis on mission oriented technological programs, e.g. Apollo, SST, Atomic Energy, etc.	36, 54, 58, 77, 111, 116, 221

c. Support of basic research by the DOD--the Mansfield proposal	24, 99, 111, 142
d. Intermittent nature of funding for science programs	17, 21, 25, 53, 133, 144, 159, 172, 178
e. Insufficient attention to social and behavioral science--proposal for a National Social Science Foundation	117, 180
V. Science and the States	139, 140, 219, 227
A. Role of State governments in the promotion of science and technology in the 19th century and up to World War II. Involvement proportionately greater than it is today, and as extensive as that of the federal government at the time. Initiation of programs in 1. Agricultural experimentation 2. Geological mapping 3. Higher education 4. Public health	
B. Decrease in relative support by State governments for technoscientific research & development after World War II due to vastly larger federal outlays (contribution of state agencies to total national R & D is about 0.5 percent, compared to about 66 percent for federal agencies). State supported R & D heavily concentrated in: 1. Health care (more than 40 percent of total states R & D). 2. Natural resources (25 percent) 3. Highways (15 percent)	254
C. Lack of support by states of basic research at colleges and universities (except for agricultural research), due to 1. General lack of interest among State governments in science per se or in academic research; teaching function of the university emphasized.	

2. State priority assigned to projects which show tangible results in a comparatively short time.	
3. Results of successful research financed by one state will be quickly available to other who did not pay for it.	
D. Recent Federal support of state technoscientific activities; some examples:	49, 223, 254
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2. Intergovernmental Cooperation Act of 1968	
3. Maritime states helped by the Sea Grant College Act of 1966	
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5. National Science Foundation Grant to Council of State Governments	69
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1. Functions	
a. Acceleration of economic development	
b. Anticipation and solution of social problems	
c. Examination of natural resource and environmental problems	
d. Injecting benefits of science and technology into State government planning and management	
e. Setting of goals and appraising of progress in areas requiring the use of science and technology	
2. Type of structure	199
a. Science Advisor to the Governor	
b. Science Advisory Council	
c. State Science Foundations	236
d. Academies of Science	
e. Combinations of some of the above	
3. State technoscientific development programs, e.g.,	154, 198, 205, 220, 228, 230, 231, 233, 237, 246, 254, 272, 275
a. Information technology	

b. Environmental research 68, 95, 266
c. Systems analysis
d. Natural areas for research
e. State museums
f. Cooperative programs between several states 214, 234, 248

4. Ineffectiveness of most state science policy structures due to
    a. Absence of clear indication of correlation between investment in technoscience and economic gain
    b. Lack of recognition of role of science advisers in the formulation of public policy
    c. Impermanence of advisers, who seldom survive a change in administration
    d. Lack of effective institutionalization of science policy in the regular structure of the legislative and executive branches

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LEADING QUESTIONS

1. How has science been involved in American politics? In foreign policy? In domestic policy?

2. What are the principal organizational components for scientific and technological decision-making in the Federal government? What are their statutory and functional relationships? Are advisory and decision-making functions realistically separable?

3. What were the principal observations of the OECD examination of science policy in the United States (1968)? What response has been made to the observations of the examiners?

4. What difficulties has the American politician encountered in attempts to deal with issues having science content? How could these difficulties be alleviated?

5. What difficulties complicate the role of the Congress in the formulation and review of science policy? What methods, proposed or in effect, have been advanced to assist the Congress in decisions relating to science policy?

6. What has been the role of the National Academy of Sciences-National Research Council in the administration of federal science policy? What circumstances led to the establishment of the National Academy of Engineering? Why are the social sciences largely excluded from the NAS?

7. What are the arguments for and against a national department of science and technology? Is there a parallel in the proposals for a national university?

8. How did establishment of the national system of land grant colleges mark a change in the functions of universities and the beginning of a new era in relationships between government, higher education, and industry?

9. What has been the role of privately owned industry in the organization and development of American science? What appears to be its probable future? How do not-for-profit R&D organizations differ, in addition to financial status, from other private industrial enterprises?

10. What role have State governments played in the development of science and technology? Is there any correlation between the quality of State government generally and its role in science and technology?

TOPIC 07 SCIENCE AND GOVERNMENT: THE SOVIET UNION

The distinguishing characteristic of Russian science has been its centralized and governmentalized character. From the time of its introduction from Western Europe by Czar Peter I, until given its present structure under the Soviet regime, science in Russia has been almost exclusively a governmental function. The structure of Soviet science, although not monolithic, is nevertheless subject to overall political and fiscal control. Soviet science is thus amenable to integrated and programed direction. It may, however, lack the flexibility and creativity of less highly structured Western science.

The Academy of Sciences was planned by Peter I and established in 1725. Initial membership of the Academy (16) was foreign. Nearly a century was required for it to become a truly Russian institution. In 1847, university functions were removed from the Academy, establishing the practice of separating research, which the Academy retained, from instruction, which was the principle function of the universities.

The autocratic and ideologically dominated governments of the Czars and the Soviets favored science insofar as it served their purposes. They had little interest in the freedom of science and did not hesitate to punish scientists for political heresies. The safest sciences in Russia were the most abstract. It is not suprising therefore that Russian scientists distinguished themselves especially in the physical sciences and mathematics.

Politcal domination of Soviet science reached its greatest extent under the dictatorship of Joseph Stalin. The most notorious political-scientific controversy of the Stalin era arose over the theories of genetics associated with the biologist Lysenko. His views, although rejected by most biologists, were favored by the political authorities. Lysenko's academic opponents suffered political reprisals. The episode gave the name "Lysenkoism" to efforts to make scientific theory conform to politcal ideology.

Coordination of Soviet science policy takes place in committees of the Council of Ministers of the U.S.S.R., notably in the State Committee for Coordination of Research and Development. Principal components of the Soviet system for science policy are the Academies of Science (of the U.S.S.R. and Union Republics), the Ministry of Higher and Secondary Specialized Education, and ministerial and industrial committees for research and development planning.

Science and technology have been accorded high priority in the allocation of public resources. Scientists and engineers are among the more prominent members of a new Soviet professional class, which Marxist ideology opposes but which practical considerations abet. It remains to be seen whether the strength of Soviet science can be channeled indefinitely along ideological lines. As social and behavioral science advances in other parts of the world, the Soviet commitment to a social ideology beyond challenge by science may be severely strained.

TOPIC 07 SCIENCE AND GOVERNMENT: THE SOVIET UNION

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TOPIC 07 SCIENCE AND GOVERNMENT: THE SOVIET UNION

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  2. Opposition of Orthodox clergy
  3. Development of non-theoretical technical knowledge

- B. Peter I, 1682-1725, and the beginning of Russian science
  1. Role of foreign scientists and advisers
     - a. Leibniz, science counselor to Peter the Great
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     - c. Influence of the European academies: common characteristics of voluntary assemblages of scholars for the advancement of knowledge (not teaching); contrasts in concepts of the relation of scientific academies to the state; "nationalist" science in France and Prussia
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       - (2) prepare extracts from foreign scientific publications
       - (3) collectively evaluate inventions submitted to them for appraisal
       - (4) provide expert answers to questions propounded by governmental authorities

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LEADING QUESTIONS

1. What are the principal organizational differences between American and Russian education and research in scientific and technical fields?

2. To what extent were technological and scientific ideas influential in pre-revolutionary Russia? What effect, for instance, did the work of D.I. Mendeleev, K.E. Tsiolkovsky, I.P. Pavlov, and Count Witte have upon the character of Russian science and technology?

3. To what extent did a "two-culture" circumstance prevail in pre-revolutionary Russian intellectual life?

4. What were the historical origins of the distinctions between the Russian universities, the technological institutes, and the academies? What is the role of the Academy of Sciences of the U.S.S.R.?

5. What was "Lysenkoism"? What was its history? Have there been parallel developments in the United States? In other countries?

6. What has been the evidence of a decentralization of scientific and technological work in the U.S.S.R. since World War II? Has the decentralization been general or selective?

7. How does public regard for scientists and engineers differ as between the U.S.A. and U.S.S.R.? What factors appear to account for the differences?

8. How has the U.S.S.R. used science as an instrument of foreign policy? How would you appraise the effectiveness of this effort?

9. Why have such observers as James Burnham and Jacques Ellul pointed to the Soviet Union as the most advanced form of technological society? Are national industrial systems generally moving toward or away from the Soviet model? What is the evidence?

10. Do the ideological parameters that circumscribe Soviet science seem likely ultimately to force it into an intellectual cul-de-sac? Will the scientific technology upon which Communist leaders have set such store ultimately contribute to the dissolution of the Marxist-Leninist regime? (Note opinions expressed by Stevan Dedijer--reference)

TOPIC 08 THE ORGANIZATION OF SCIENCE IN WESTERN EUROPE

The historical development of government-science relationships in Western Europe has followed two contrasting patterns. Prototypes for these general patterns are found in England, where a laissez faire attitude toward science long prevailed, and in France, where government has been the principal patron and organizer of science. These patterns are no longer clearly defined, and there are many variations and intermediate stages in other European nations. But the tendency among the civil law states of continental Europe has been to follow the French system of centralized, government-sponsored science; whereas in the United Kingdom and the smaller maritime states of northwest Europe the relationships between government and science were similar to those also prevailing in the United States. The basis for these differences has lain not so much in attitudes toward science as in prevailing concepts of jurisprudence and public administration. Similar contrasts may be found with regard to governmental responsibility for education, economic affairs, and the fine arts.

The chartering of the Royal Society in London in 1662 marks the beginning of organized science in England. During the 18th and 19th centuries a modified laissez faire prevailed with respect to science and technological innovation. England was a leader in the industrial revolution and it was industrial technology, encouraged by the inducements of a market economy, that flourished. Not until mid-twentieth century did the British government become seriously involved in science policy. In the post-World War II era, science became a political issue, and major innovations occurred in government organization.

In France, government sponsorship of science may be said to have begun with the establishment of L'Academie des Sciences in 1666. Advancement of science and technology, at least in theory, became a continuing function of French government. In the years between World Wars I and II the vigor of French science appeared to decline, and in 1958 a major reorganization of the machinery of government for the advancement of science and technology occurred. An effort has been made to preserve the advantages of centralized support and coordination and to gain flexibility and diversity, involving the industrial sector and the research laboratories and university faculties in partnership in planning.

The period since World War II has been marked by a resurgence of science in Germany, which had suffered heavy losses during the Hitler regime and the war years. European regional cooperation for science and technology has greatly increased. Adding to the informal collaboration of individual scholars and scholarly societies, new organizations have been established for cooperation in atomic energy (CERN, EUROCHEMIC, EURATOM) and space research (ESRO and ELDO). The high cost of advanced scientific research and technological innovation makes international cooperation a practical necessity in many fields of inquiry for most European states.

TOPIC 08 THE ORGANIZATION OF SCIENCE IN WESTERN EUROPE

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TOPIC 08 THE ORGANIZATION OF SCIENCE IN WESTERN EUROPE

TOPICAL OUTLINE	REFERENCE KEY
I. Historical Roots of Science in the West (cf. Topic 02)	6, 117, 130
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B. Birth of modern science in the Renaissance 1. Patronage of science 2. Science in the universities	
C. Emergence of organized science (Cf. Topic 04)	296
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2. Government-sponsored academies, e.g., L'Academies des Sciences, 1666; The Royal Observatory at Greenwich, 1675; academies established in Prussia, 1700; Sweden, 1739; Denmark, 1742; Netherlands, 1808; Austria, 1847	206, 266, 334
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3. Influence of the relations among science, technology, and industry in shaping popular concepts of science in English-speaking countries	
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1. Realization during the first World War of the unity of scientific knowledge which supports both the military and the industrial effort Recognition of need to put state support of science on something more than an ad hoc basis	
2. Establishment of science advisory committees and the beginning of an integrated science policy	
3. The Haldane Committee of the Privy Council (1915), which became the Department of Scientific and Industrial Research (1916)	203, 261
4. The 'Million Fund' and the Research Associations set up to support scientific research	187
5. The Report of the Haldane Committee on the Machinery of Government (1918) resulted in the creation of a Ministry of Health, and a Medical Research Council (1920). An Agricultural Research Council was established in 1931	307, 312

6. A professional organization--the National Union of Scientific Workers was established in 1918, which became the Association of Scientific Workers in 1927
7. The Tizard Committee for the Scientific Study of Air Defense (1934) led to the development of radar

D. Science during and after World War II — 130, 140, 153, 179, 219, 228, 253, 281, 288, 293, 301, 314, 320, 321

1. Mobilization of British science during World War II. Cooperation with the U.S. in the development of the atomic bomb, and the large scale manufacture of penicillin — 280
2. Attempt to apply methodology of the natural sciences to improvement of efficiency of war led to a new branch of applied science-- Operations Research
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LEADING QUESTIONS

1. What have been the historical relationships between government and science in the United Kingdom? How do these relationships compare with those characteristic of the United States, France, Germany, or the Soviet Union?
2. What is the "two cultures" thesis of Sir Charles P. Snow? Is its argument valid generally for modern society, for England, or for a limited segment of British society? What recent developments in the U. K. seem likely to influence the "two cultures" dichotomy in that country in the future?
3. What are the principal components of the machinery for the formulation and execution of science policy in the German government? How do they compare with instruments of science policy in the United States, France, United Kingdom, and the Soviet Union?
4. In what respects has the relation of science and technology to government differed in France from its relationship in the English-speaking countries? To what extent have French government-science relationships provided a model for other countries?
5. What obstacles have stood in the way of greater collaboration between the Western European nations in the field of science and technology? Has the degree of cooperation been increasing or decreasing?
6. What role has scientific and technological research and development played in the unification of Europe since 1945? What has been the contribution of European regional agencies for nuclear research and space technology?
7. What are the causes of the "Technological Gap" between Western Europe and the U.S.A.? Is it really one gap, or are there several gaps? What efforts are being undertaken, and could be undertaken, to narrow its extent?
8. What has been the function of the independent research institute in the development of European science? Are these comparable or analogous to institutions in the United States, the United Kingdom, or the Soviet Union?
9. How far can smaller European nations afford to invest in advanced scientific and technological research and development? Are they threatened by technological "imperialism"? What are their alternatives?
10. What valid comparisons or generalizations can be made regarding public support for science and technology in Western Europe and in the United States and the Soviet Union? Do the major Western European states tend to spend a higher or lower proportion of their national incomes on scientific research and development?

TOPIC 09 INTERNATIONAL TECHNOSCIENTIFIC COOPERATION

From its very beginnings science, as an intellectual enterprise, has transcended political boundaries. However with the growth of political ideologies, and notably with the growth of national states and nationalism, communication among scientists and scientific organizations has been complicated by international politics.

It therefore follows that the organization of world science has developed upon international lines. International scientific and technical organizations are generally organized upon the basis of national membership (unofficial as well as official). There is a tendency, however, for the organizations associated with the United Nations to assume an integrated world character rather than to emphasize their multinational basis (World Health Organization, World Meteorological Organization, and Food and Agriculture Organization).

Antecedents of permanent international scientific organizations were international scientific congresses, beginning in mid-19th century, and the establishment of international associations of scientists. In 1875, establishment of the International Bureau of Weights and Measures near Paris marked the beginning of permanent, operational, international technoscientific organizations. Today international technoscientific cooperation is organized around (1) temporary mission-oriented programs, (2) permanent nongovernmental professional associations, and (3) intergovernmental agencies. The first category comprises temporary congresses, committees, or programs constituted for a specific duration, such as the International Geophysical Year and the International Biological Program. Representing the second type of organization is the International Council of Scientific Unions and its constituent bodies. But there are many other technical, scientific, and professional organizations that serve in various ways to strengthen the matrix of the international scientific community. The third type is represented by the United Nations and its affiliates, and administers continuing scientific and technical programs.

The global extension and impact of the technoscientific culture make the growth of international and world organizations for scientific and technological purposes almost inevitable. Management in the oceans, in the atmosphere, in outer space, in the great international river systems lies in large measure beyond the capacity of individual national governments. The construction of feasible and effective organizations for the worldwide management of science and technology is one of the great challenges to human intelligence today.

The voluntary character of international cooperation is a source both of strength and of weakness to scientific and technological efforts on a global scale. Cooperative efforts, such as the World Weather Watch, serve the self-interest of all nations; but whenever cooperation impinges upon national military or economic advantage, its existence becomes precarious. The future of worldwide operational efforts in science and technology in all probability lies with transnational organizations responsible to a representative international body such as the United Nations rather than directly to national states.

TOPIC 09 INTERNATIONAL TECHNOSCIENTIFIC COOPERATION

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TOPIC 09 INTERNATIONAL TECHNOSCIENTIFIC COOPERATION

TOPICAL OUTLINE	REFERENCE KEY
I. Science and Advanced Technology as International Enterprises	125, 162, 190, 198
A. The universal character of scientific knowledge	
B. The mobility of scientists and scientific and technological concepts	
C. International diffusion of technology	
II. The Necessity for International Techno-scientific Cooperation	30, 32, 45, 76, 127, 132, 149, 218, 251, 288
A. The ultimate indivisibility and limitations of the planetary environment and the biosphere	40, 45, 155, 203, 292, 299
B. Limitations of national political control over the air and the oceans and over physical and biological interactions in the biosphere	18, 122, 151, 186, 269
C. International cooperation becomes necessary when a phenomenon 1. Transcends political boundaries and cannot be controlled by unilateral action (e.g., weather reporting or modification, control of nuclear fallout, international telecommunications, fur seals, whales, oceanic conditions generally)	27, 28, 86, 100, 123, 124, 148, 175, 184, 202, 231, 259, 261, 262

2. Could only in part be controlled unilaterally, and international cooperation could greatly ease the burden and enhance the effectiveness of national action (e.g., medical quarantine, protection of migratory birds, exploration of outer space, aviation safety standards)	18, 81, 136, 200, 227
3. Could not be dealt with unless intellectual and material resources that are dispersed and unevenly concentrated around the world are brought into some form of cooperative relationship (e.g., technical assistance efforts to countries suffering from physical, economic, and social deterioration)	140, 262, 276, 301
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  1. Bessel's Sky Chart Project (started 1824)
  2. International Polar Year, 1882-83

B. International congresses
  1. 1847 International Congress of Economists--Brussels
  2. 1848 International Agriculture Congress--Brussels
  3. 1851 International Health Congress--Paris
  4. 1853 International Statistical Congress--Brussels
  5. 1860 International Congress of Chemistry--Karlsruhe
  6. 1862 International Congress of Geodesy--Berlin

C. International associations
  1. 1861 Universal Society of Ophthalmology--Paris

2. 1872 International Meteorological Committee--Leipzig
3. 1900 International Association of Academies--Gottingen

D. International bureaux
1. 1875 International Bureau of Weights and Measures--Paris
2. 1921 International Hydrographic Bureau--Monte Carlo

E. Research stations
1. Naples Zoological Station--1870
2. Jungfraujoch Scientific Station--1930

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c. World Health Organization, WHO--1946	3, 72, 73, 174, 213, 300
d. World Meteorological Organization, WMO--1947	46, 204
e. International Atomic Energy Agency, IAEA--1956	5, 153, 173

- f. International Civil Aviation Organization, ICAO

B. Other intergovernmental-international organizations
- 1. International Computation Centre, ICC--1961
- 2. International Institute of Refrigeration, IIR--1920
- 3. International Telecommunication Union, ITU — 69, 218
- 4. Intergovernmental Maritime Consultative Organization, IMCO
- 5. Permanent Commission of the International Fisheries Convention--1946
- 6. Intergovernmental Oceanographic Commission, IOC--1960-61

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- 1. International Council of Scientific Unions--founded 1919 as the International Research Council and re-established as ICSU in 1931 — 1, 4, 12, 89, 229
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  - b. Fifty-seven (1964) national members (represented by national academy, research council, or directly by a government)
  - c. Scientific committees
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    - (2) Scientific Committee on Oceanic Research, SCOR--1957
    - (3) Scientific Committee on Antarctic Research, SCAR--1958
    - (4) Scientific Committee on Problems of Environment, SCOPE--1970 — 306
  - d. Inter-union committees (limited task and duration)
    - (1) International Geophysical Committee, CIG--1959
    - (2) Committee on Frequency Allocations for Radio and Space Science, IUCAF

e. Special committees	
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(2) Committee for the International Years of the Quiet Sun, IQSY--1964-65	256
(3) Committee for the International Biological Programm SCIBP	242
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(2) Federation of Astronomical and Geophysical Services, FAGS--1956	
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LEADING QUESTIONS

1. What are the principal categories into which international organizations for science and technology are customarily grouped? What are the principal criteria for their classification?

2. To what extent does the United Nations function as an international organization for science and technology?

3. What have been the principal contributions of UNESCO to the advancement of science and technology, and how have its scientific activities been organized?

4. What are the prospects for international scientific and technological organizations acquiring an identity independent of the system of national states? Is there a significance in the term "World," in the name of several organizations? What problems or dangers or advantages might result from a world scientific organization that was independent of national governments?

5. What has been the role of nongovernmental professional associations in the international organization of science and technology? What have been the contributions of these associations?

6. In view of the generally high prestige of science and scientists, what accounts for the relatively low priority accorded international scientific cooperation by many governments? What aspects of international cooperation are most widely resisted and why?

7. In what matters is international scientific cooperation most urgently needed today? What are the principal barriers to this cooperation?

8. What specific measures might be taken to strengthen international scientific cooperation? What forms of cooperation appear to have worked most effectively thus far?

9. What has been the contribution of international scientific conferences and seminars to international cooperation? Are gatherings like the Pugwash Meetings significant?

10. What are the implications for international relations in the highly differential rate of scientific and technological development in the "advanced" and newly emerging nations? Is technoscientific "imperialism" a possible consequence of the inability of underdeveloped countries to cope with science-induced problems and the necessity for recourse to technical assistance from more "advanced" societies?

TOPIC 10 TECHNOSCIENCE IN THE DEVELOPING COUNTRIES

Modern science had its genesis in Western Europe in an historical period coincident with the rise of nationalism and the expansion of European political control to nearly all parts of the world. The science brought from Europe to the non-European world was not only an alien force, but was also an aspect of an alien and threatening civilization. In a few cases--most notably in Japan--science was seen as separable from other aspects of Western civilization. Japan became a modern scientific and technological power while retaining many of the values and characteristics of its traditional civilization.

As many former dependencies gained national status after World War II, efforts were made through international technical assistance to develop science and technology in these new nations. Participating in this assistance were the United Nations and their affiliated organizations; multilateral groups such as the Organization for Economic Cooperation and Development, the North Atlantic Treaty Organization, and the American Alliance for Progress; and bilateral arrangements of which the so-called foreign aid program of the United States was the principal example. In 1963, the United Nations sponsored at Geneva a Conference on the Application of Science and Technology for the Benefit of the Less Developed Areas, with 96 governments represented. The efforts that have gone into developing scientific competence in the new nations have been impressive. Unfortunately, the results have frequently been disappointing.

A basic reason for the slowness of the scientific way of life to take root in the non-Western world is perhaps because science itself has been an aspect of Western culture. Unless, as in Japan, science found an accommodating conjunction of values, it could not establish itself. During the nineteen sixties, there was a rapid development of technological capability in the People's Republic of China, but the status of science in China has been difficult to assess. Science in the Western world has been the outgrowth of at least three centuries of cultural change. It is not surprising that most new nations have found it difficult to make this transition in a single generation. Moreover, it should also be remembered that science is not as yet a major interest or influence in the lives of large numbers of people even in the most technoscientifically advanced countries.

A secondary factor in retarding the growth of science in the new nations has been the bias of the aid-giving powers toward economic as the prime mover of societies. A widely prevailing assumption of international technical assistance has been that if national economies can be activated to reach some specified "take-off" point, development of the more advanced aspects of the technoscientific culture automatically will follow. Unfortunately, economic planning as it has been applied in most of the new and developing nations does not appear to have enabled them to generally improve the quality of life for their peoples or to have protected or improved the viability of their biophysical environments. Specific successes have been achieved, but the technoscientific superculture through which the future state of the world may be determined is still overwhelmingly concentrated in the nations which gave it birth.

TOPIC 10 TECHNOSCIENCE IN THE DEVELOPING COUNTRIES

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TOPIC 10 TECHNOSCIENCE IN THE DEVELOPING COUNTRIES

TOPICAL OUTLINE	REFERENCE KEY
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LEADING QUESTIONS

1. What have been the principal effects of science and science-based technology on non-Western traditional cultures? Is there a "scientific culture" distinct and separable from Western traditional culture?

2. Have certain of these effects been inherent in contradictions between science and traditional culture, or have they followed from the manner of the introduction of science and advanced technology, or both?

3. What were the objectives of the United Nations Conference on the Application of Science and Technology for the Benefit of the Less Developed Areas? What were the achievements of the conference? What were its significant omissions?

4. What factors seem to influence the extent to which science and advanced technology are accepted (or rejected) in traditional societies? What may explain the contrasting reception of Western science in Japan, China, India, Indonesia, and the Arab states?

5. Is science, as a method of thought, consistent with the political assumptions underlying the creation of new "sovereign" nations in Africa and Asia?

6. What are the principal obstructions to the development of science in traditional cultures where there is no overt opposition to science per se--in much of Central and South America, for example?

7. What are the more important institutional arrangements for introducing and cultivating science in newly emerging nations? E. g., what international organizations or agreements have been developed to assist this process?

8. Are scientific and economic developments always compatible in the new nations--or have there been conflicting effects? Can you cite specific examples of incompatible objectives?

9. Can the development process be made amenable to broad-based scientific concepts and methods? If so, how might this be accomplished and where should the initiative be located?

10. Given the present exponential growth of science and advanced technology in Westernized countries, is there any real prospect that the new nations can "catch up" with the more advanced societies--or will the knowledge gap widen?

III

POLICY PROBLEMS OF SCIENCE AND TECHNOLOGY

The five topics comprising this section cover some of the larger problem areas of public policy that have resulted from the advancement of science and technology. In Topics 11, The Politics of Science and Technology, and 12, Administration of Research and Development, emphasis is on establishing the direction, priorities, and allocations of money for scientific and technological development in the United States. In the remaining topics of this section American experience is also emphasized, but attention is given to policy problems in other national contexts. Topic 13 is closely related as it examines methods of controlling the direction of technoscientific development and its effects on planning for the tested application of selected technologies. Topics 14, Science, Human Rights, and the Role of Law, and 15, Managing the Technoscientific Superculture, deal with policy problems growing out of the impact of science and technology upon the lives of individuals. Advancements in medicine, engineering, genetics, pharmacology, and industrial chemistry have given rise to novel circumstances in which the rights of individuals and of society cannot always be defined by historical precedent. The focus of all topics in this section is upon problems generated by the growth of technoscience, and the policy issues that arise in consequence of these problems and of the efforts of society to cope with them.

TOPIC 11 THE POLITICS OF SCIENCE AND TECHNOLOGY

Although the formal structures of government-science relationships may be studied comparatively, it is more difficult to compare (in any detail) the actual course of politics through which a nation's policies for science and technology are shaped. In any nation, the development of science and technology has been influenced by unique factors of history, institutions, and personal leadership. Science policy is seldom shaped primarily out of concern for the advancement of knowledge. In the United States, no less than in other countries, considerations of national security, economic growth, fear of illness, and international prestige have influenced the direction of science policy.

In the United States, the politics of science during the 19th century was strongly influenced by rivalry among several leading scientists. Political attitudes toward the Federal role in science reflected popular beliefs regarding the proper functions of government in general, and the Federal government in particular. The principal scientific functions of government were in pursuance of other objectives, chiefly military in the years before the Civil War. In the post-Civil War years, agriculture became a major focus for applied science and, at the close of the century, the conservation of natural resources emerged as a related field for the application of scientific knowledge.

It was not until science assumed the proportions of a major national enterprise in the years following World War II that it became a significant political issue. Its increasing importance explains its growing political involvement--a relationship that some scientists have been reluctant to concede. In the immediate post-War period, questions of how to manage the recently liberated energy of the atom were paramount, followed by debate over the nature of a national institution to promote the advancement of science. The Atomic Energy Commission (1946) and the National Science Foundation (1950) were outcomes of these political issues. This post-War era also saw the expansion of the National Institutes of Health into one of the world's greatest biomedical research establishments.

Success of the Soviet Sputnik in 1957 stimulated new efforts to strengthen physical science and led directly to the Space Program and establishment of the National Aeronautics and Space Administration. The structure of advice and coordination for Federal science policy became a political issue, and led to structural innovations. But increasingly, the politics of science and technology reflected public concern over the wise use of knowledge. Among the political issues affecting the direction of science policy have been nuclear fallout, pesticides, environmental pollution, dangerous drugs, Supersonic Transport, and the national investment in basic science. Arguments have been advanced from several sources for a high-level review of the consequences of scientific and technical innovation. By the early nineteen seventies there was widespread concern in most scientifically advanced countries over priorities in scientific research and development, and for better ways to determine them. (See Topic 12)

TOPIC 11 THE POLITICS OF SCIENCE AND TECHNOLOGY

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LEADING QUESTIONS

1. What circumstances have drawn scientists into politics? How have the prevailing values and attitudes among scientists and their social status affected their political activities?

2. What criticisms have been directed toward high-level science policy advice in government? What has been the source of these criticisms and the reasons advanced to refute them? What alternatives have been suggested?

3. What events or reasons have been the leading factors in Federal support for scientific and technological activities? Does Congress tend "to do the right things for the wrong reasons?"

4. How would you evaluate the fears of science elitism as expressed by Lapp, Price, and others? What threat do they perceive to political responsibility and democratic institutions? What remedies are suggested?

5. What has been the personal influence of scientists in shaping U.S. science policy? Has the influence of men like Powell, Agassiz, Pinchot, and Bush led to developments in government science different from what objective analysis of national needs and interests would have indicated?

6. What have been the principal problems of the scientist-employee in government? What issues have arisen over political loyalty, national security, accountability to management, personnel and budgeting procedures, and freedom of inquiry?

7. What were the principal issues debated in the process of establishing the National Science Foundation? To what extent do these issues remain unresolved? What arguments have been advanced for and against a separate Social Science Foundation?

8. Does the public interest imply a need for the surveillance and control of investigation, experimentation, and allegation made in the name of science? If so, how should this supervision be provided? By law? By the scientific community? Through the administrative process?

9. Does the future viability of democratic government require an increased public understanding of science? Is an outlook of technoscientific determinism compatible with a commitment to self-government?

10. When moral or political judgments and scientific evidence are contradictory, which should govern public policy?

TOPIC 12 MANAGEMENT OF RESEARCH AND DEVELOPMENT

Public investment in scientific research and technological development has become mandatory in any modern nation with pretensions to power. The large amounts of money required in either absolute or relative terms, and the practical necessity for establishing priorities in the allocation of public funds among the several fields of science and technology, have made the administration of R & D a major policy area in technoscientifically advanced countries.

Specific issues regarding R & D include the following: (1) How much or what percentage of national income should be allocated for R & D and by what criteria? (2) What should be the distribution of available R & D funds among the fields of science and technology and among claimant institutions? (3) Who should determine priorities of R & D? (4) How can creativity in R & D be increased?

In the United States, at least, no clear or decisive answer to any of these questions has been forthcoming. Resolution of each of these issues has been by traditional political means. No scientific basis for choice in the shaping of policy for R & D has yet been generally accepted. Several committees of the Congress, scientific bodies, and a number of civic and educational organizations, have studied the assessment of the effects of science and technology on society and have proposed new methods for the review and evaluation of scientific and technological innovation. (See Topic 13)

The administration of R & D gives rise to sets of problems on two different levels. On the macro or national level, the allocation of funds among the fields of inquiry and among institutions are major policy questions. Closely associated is the geographical distribution of R & D money and its effects upon academic strength and economic growth in the principal regions of the country. On the micro or local-institutional level, a large number of specific issues can be identified.

Among these issues are methods for determining research priorities, promoting creativity, overcoming institutional and personal obsolescence, and avoiding undesired consequences of technological innovation (e.g., foaming detergents).

In governmental and industrial laboratories, relations between the scientific and technical staff and nonscientist administrative supervisors have frequently been difficult; the objectives of research and of mission-oriented development are often very different, and if not understood by the laboratory personnel, they may lead to conflicting viewpoints regarding the nature of the work to be done.

Perhaps the major policy problem in the administration of R & D is the bringing together of the resources of government, industry, universities, and research institutions into coherent purposeful, and yet accountable relationships. This combination of forces can form a powerhouse for the advancement of science and technology and for their wise use. The space effort provides a general model for the coordination of these forces on specific tasks. But these combinations pose serious questions for the theory and practice of responsible democratic government.

TOPIC 12 MANAGEMENT OF RESEARCH AND DEVELOPMENT

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TOPICAL OUTLINE	REFERENCE KEY
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LEADING QUESTIONS

1. How might it be determined that the existing level of support of basic research in an area of science is not sufficient to maintain the rate of growth of that field: would you ask experts in that field alone, or would you also call in outsiders?

2. An economist, Denison, has calculated that the rate of return from investments in R & D programs has been only about that of investments in nonresidential real estate. Would you accept the analogy between R & D expenditures and real estate investments?

3. What has been the effect of Federal support of science on the existing character of the universities doing scientific work? Has the rise of national research laboratories diminished the relative importance of the universities in scientific research?

4. Is there really a national policy for the support of basic scientific research? What would be the implications of such a policy, how could it be implemented in practice, and what are some of the arguments against a single Federal "science budget"?

5. Some writers have charged that there are alternative programs, e.g., a war against poverty or improvement of existing health facilities, which would not require any basic research for their implementation and would promise a better rate of return in social and economic goods than the space race or high energy physics. Have their arguments taken all relevant factors into account?

6. Toulmin, Weinberg, and others have attempted to formulate criteria for the evaluation of proposals for scientific research. What factors have they taken to be important? Do their illustrative evaluations seem satisfying?

7. From an overview of the present funding practices of Federal support for basic scientific research, would you judge that our estimates of the probable returns from such expenditures have been based upon the cultural or the mission-oriented values of science? What consequences would follow from the method of estimating benefits?

8. What would be some probable outcomes if Federal support of science were drastically curtailed?

9. What factors should be considered in allocating resources among the various sciences? Is it possible to predict, on the basis of present trends, any changes in the relative amounts of support of the physical, biological, and social sciences?

10. What are some of the proposals that huve been made to obtain more disinterested, more broadly beneficial, and more responsible decisions regarding the emphasis and funding of research and development projects?

TOPIC 13 TECHNOLOGICAL FORECASTING AND ASSESSMENT

Experience with the consequences of technological innovation has indicated the desirability of foreseeing the possible effects of technological change. Technological forecasting has become of special concern to persons responsible for social, economic, or industrial planning. Investment houses, banks, and many business firms have an obvious concern with the economic implications of technological change, and they are therefore anxious to foresee the course of technological development. Governments must also be alert to the character and implications of technological change, as nearly every facet of public policy could be affected by the complex interactions among modern technologies.

The objective of forecasting is not only to estimate the direction in which technology is likely to develop, but also to discover the directions in which it can and should (or should not) move. This examination of the implications and potentialities of technology is called technology assessment. Concern for the effects of technology has been stimulated by the environmental and psycho-physical consequences of a large number of technological innovations. Examples range from the radiation hazards of microwaves propagated by household electronic appliances, to the ecological consequences of pesticides, to the physiological and atmospheric effects of supersonic flight.

One of the more highly developed systems of assessment is in the area of pharmacology and medicine, as provided in the United States by the Food and Drug Administration and the National Institutes of Health. The rapidly developing field of chemical technology has created a need for greater information and controls over new products, and an international registry of chemical compounds has been proposed. A more positive approach to technology assessment is the analysis of the kinds of technologies needed to attain specific social goals. Thus assessment can be used to discover and develop beneficial new technologies as well as to protect against harmful effects.

It is difficult and, in general, unwise to separate technological forecasting and assessment from its total ecological and social context. Assessment of the costs, risks, and benefits of a technology requires some standards of welfare or value. Moreover, the conditions required for the development or control of a particular technology may be of a social, economic, political, or ethical nature not directly evident in an isolated examination of the technology itself. Technological forecasting and assessment tend, therefore, to induce more comprehensive systems analyses of all major trends in society, leading toward a "science" of possible futures or "futurology".

TOPIC 13 TECHNOLOGICAL FORECASTING AND ASSESSMENT

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TOPICAL OUTLINE	REFERENCE KEY
I. Need for Technological Forecasting and Assessment	5, 21, 27, 43, 47, 54, 63, 70, 94, 123, 127, 134, 138, 152, 159, 182, 183, 204, 319, 336, 338
A. Danger of unforeseen side-effects of powerful new technologies. The large increase in world population with reduced margins for error means that there are very few areas in which risky experiments can be conducted, and consequences are less likely to be confined locally	71, 93, 99, 133, 144, 166, 167, 177, 185, 248, 266
B. Basis for economic choice and investment, as well as for rational development planning. Rapid advances in science and technology necessitate a high selectivity on the part of the decision maker not only at a national level, but at the level of the individual industrial enterprise. Forecasting techniques are valuable tools in identifying alternate possibilities for choice	34, 36, 73, 77, 80, 82, 100, 114, 116, 150, 160, 161, 169, 174, 218, 236, 242, 298, 323
C. Systematic means are needed to estimate impacts which technological developments are likely to have on society in the future, and for guiding the application of new knowledge toward goals set by society. Also necessary to determine priorities of fields in which new knowledge is urgently needed	28, 48, 49, 66, 72, 75, 78, 103, 121, 122, 128, 139, 141, 142, 162, 186, 192, 227, 263, 272, 278, 295, 324, 350, 359, 362

II. Early Efforts at Forecasting	39, 102, 198, 208, 317
A. Observed correlations between stellar constellations and the annual floods in the valley of the Tigris and Euphrates gave the Mesopotamian priests--the first known forecasters--an enormous political and economic power	202
B. Implicit forecasts in the Middle Ages and the Renaissance--da Vinci, Bacon's New Atlantis, etc.	198
C. Forecasts made to promote specific developments, e.g., aircraft, space travel, and communications satellites	229, 244
D. Forecasts used as warning against dangers in specific technologies such as electronic eavesdropping and genetic engineering	202
E. Other wide-ranging forecasts up to World War II	19, 163, 209, 271, 285, 321, 343, 369
F. Science fiction as a semi-intellectual exercise with emphasis on entertainment value--the novels by Jules Verne, H. G. Wells, Aldous Huxley, and George Orwell	107, 414
III. Systematic Technological Forecasting	17, 25, 31, 32, 46, 79, 83, 88, 158, 159, 179, 190, 199, 202, 212, 224, 225, 275, 299, 318, 328
A. Inclusion of social, technological, and military environments in forecasting--National Research Council report of 1937, "Technological Trends and National Policy"	349, 352

B. Utilization of forecasting techniques by the U.S. Armed Services	117, 119, 222, 237
1. Air Force Office of Scientific Management--Project Forecast	120, 315, 385
2. Annual long-range forecast issued by the Army Materiel Command	
3. The Naval Materiel Command's forecasts	35, 226, 403
4. Military forecasts undertaken by universities and by nonprofit organizations, such as the RAND Corporation and the Hudson Institute	235, 279, 294, 305, 306, 405
C. Nonmilitary forecasts by government agencies dealing with availability of key raw materials, energy sources, labor supply, etc.	4, 240, 252, 292, 293, 312, 313, 362, 386, 391, 393, 399
1. The Report of the President's Materials Policy Commission (1952)	404
2. The National Power Survey (1964)	400
3. Forecasts by the Bureau of Mines and the Department of the Interior about future availability of petroleum fuels	
4. Study by the Department of Labor of future technological trends in major U.S. industries and their impact on wages, labor requirements, and availability of manpower	386
5. Federal agencies continuously concerned with the future impact of technology include PSAC, FCST, OST, NSF, Department of Commerce, NBS, FDA, NIH, AEC, and NASA, as well as ad hoc groups	340, 387
D. Nongovernmental groups dealing with specific aspects of technological forecasting	
1. Resources for the Future, Inc.	313
2. Aerospace Industries Association	194
3. American Academy of Arts and Sciences--"The Year 2000"	195, 196

4. Bertrand de Jouvenel's "Futuribles" Program	239
5. Robert Jungk's Project on "Mankind 2000"	302
6. Institute for the Future	252, 278, 295, 320
7. International organizations such as OECD, EURATOM, ICAO	250
8. Private industry	67, 114, 129, 351, 408, 409, 417
E. Some current methods of technological forecasting	37, 64, 97, 105, 109, 118, 140, 147, 157, 202, 212, 216, 364
1. Exploratory forecasting starts from current basis of knowledge and attempts to predict the technological state-of-the-art in a given time frame	147, 199, 202
a. Trend extrapolation to either a straight line fit or an S-shaped expectation	52, 126, 314, 386
b. "Genius Forecasting" by individual experts	277, 307, 322, 383
c. "Brainstorming"--group meeting deliberately set up to stimulate "way out" thinking	
d. The "Delphi" technique--forecasts made by panels of experts not in direct communication with each other	18, 20, 30, 50, 151, 175, 176
e. "Cross Impact" studies--the effects of several alternate developments on the subjects of the forecasts	30, 115, 280
f. "Gaming" and "Scenario Writing"--participants asked to simulate a specific role in a "scenario." In "Scenario Writing," the emphasis is on the critical branch points, where small influences may have large effect on outcome	65, 191, 193

g. Modeling and simulation	54, 85, 115, 203, 268, 297, 320, 327, 336, 358
2. Normative forecasting first assesses future goals, and works backward to the present--"Inventing the Future"	3, 59, 104, 147, 272
a. Morphological Analysis--a technique for identifying, indexing, counting, and parametrizing the collection of all possible devices to achieve a specified functional capability. Can also be used for identifying and counting all possible means to a given end at any level of abstraction or aggregation	132, 420
b. "Operations Research" and "Systems Analysis" as forms of self-fulfilling technological forecasts (cf. Topic 15)	54, 84, 112, 113, 360, 374
3. Drawbacks of the exploratory-normative classification. Need to look beyond this for creative synthesis and additional perspectives	2, 33, 56, 147, 148, 164, 165
IV. Technology Assessment	11, 40, 41, 60, 76, 86, 93, 101, 106, 136, 139, 154, 180, 181, 231, 265, 345, 347, 390, 392, 396
A. The nature of technology assessment	98, 110, 335, 344
1. A form of policy research which provides a balanced appraisal to the policymaker	195, 232, 334, 387, 391, 393
2. Identifies policy issues, assesses the impact of alternative courses of action, and presents findings	130, 197, 381, 391

3. Analytical methods which vary from case to case, and appraise the nature, significance, status, and merit of a technological program	29, 45, 125, 233, 363, 366, 395, 397, 398
B. The scope of technology assessment	13, 14, 90, 92, 93, 162, 166, 196, 210, 231, 329, 330
1. Measurement of physical parameters such as climate and weather modification, famine, epidemics, radiation effects	197, 217, 258, 270
2. Establishment of cause-and-effect relationships, with special emphasis on second- and third-order effects	9, 149, 205
3. Risk-versus-reward ratios for different nations, e.g., use of DDT in India may be desirable, but not necessarily so in the U.S.A.	
4. Emphasis on short-term impacts that can be measured by natural science parameters, but long-range effects such as possible changes in values, attitudes, or institutions also considered	89, 98, 108, 121, 145, 149, 172, 178, 185, 195, 200, 207, 219, 320, 407, 410
C. Some areas in critical need of technology assessment	99, 110, 112, 155, 177, 187, 204, 221, 258, 259, 287, 308, 331, 340
1. Energy production from fossil fuel, nuclear plants, and other sources	62, 69, 111, 184, 289, 354, 376
2. Phosphates and other substances in water	217
3. Short- and long-term effects of pesticides	171, 217
4. The role of the automobile in transportation	10, 28
5. Supersonic passenger aircraft	26
6. Further growth of the cities	42, 291, 384

7. Fertility control drugs	130, 269
8. Genetic Engineering	367, 379, 416
D. Steps involved in technology assessment	85, 153, 189, 332, 340
1. Identification of all areas influenced by a program—in physical, social, economic, and legal sectors	91, 173, 333, 341
2. Establishment of cause-and-effect relationships, including indirect effects	54, 84, 112, 113, 205
3. Determination of alternative methods to implement the program	51, 260
4. Identification of alternative programs to achieve the same goals and possible impacts associated with them	51, 260
5. Evaluation of all the bad, as well as good, impacts of the program	171, 205
6. Presentation of findings from the analysis, and recommendations	45, 125

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LEADING QUESTIONS

1. What are the distinctions between technological forecasting and assessment, and how are they related?

2. Who attempts to forecast technological development and why?

3. What is the difference between exploratory and normative forecasting? Are they mutually exclusive or reinforcing or neither? Is there a more valid way of understanding the modes of forecasting?

4. How may computers be used as tools of forecasting or assessment?

5. What are the merits of reproducible versus non-reproducible techniques, e.g., the Delphi technique? What are their strengths and weaknesses? For what kinds of problems are non-reproducible techniques most useful? Least useful?

6. What institutional arrangements have been suggested to improve the quality of technological forecasting and assessment?

7. What are the relationships between technological change and the socio-economic structure of society? Contrast or compare relationships under socialism, free enterprise, and traditional forms of society.

8. What are the possible roles for technological forecasting and assessment in public planning? Cite examples of how predictive approaches to technology have been used (e.g., 1937, National Research Council report), and analyze the validity of their assessments.

9. Has science fiction and Utopian literature had any measurable effect upon the history of technology? What have been the effects of forecasts appearing to be self-fulfilling or self-defeating?

10. Can the needs of society be identified and defined for optimal use of technological possibilities? If this could be done, what means would be employed?

TOPIC 14 SCIENCE, HUMAN RIGHTS, AND THE ROLE OF LAW

Science and technology change relationships among individuals, and between individuals and society. For example, biomedical knowledge has changed public attitudes toward various aspects of disease and has placed upon government new responsibilities for protecting the public welfare. New forms of information gathering, new techniques of crime detection, new pharmaceutical products, and new forms of energy and of industrial organization create problems of human rights and justice for which historical experience provides no adequate precedent. Moreover, the advancement of science sharpens debate over the meaning of "human rights" and the substance of "justice". Are "rights" and "justice" no more than social conventions, unsupported by any knowledge derived from science?

Law as a social institution is therefore under stress in attempting to accommodate traditional attitudes and assumptions to the realities of technoscientific society. Before the advent of science, law rested securely upon social or political "truth". In Medieval Europe, witchcraft was a legal fact validated by popular belief. When the growth of scientific knowledge undermined belief in witches, the laws punishing witchcraft ceased to be enforceable. Witchcraft had ceased to be a social or political truth. Law stabilizes and protects the established social order, and changes in the law reflect changes in society. But an accelerating rate of technoscientific change may exceed the capacity of social attitudes and institutions to make corresponding adjustments. The volume of law making, in the United States for example, has increased over the years largely (although often indirectly) because of the new factors introduced into society by science and technology. And yet the process of law revision does not keep pace with technoscientific change.

Several new fields of law or legal theory have emerged as a direct consequence of technoscientific innovation. Among these new areas for legal concern are atomic energy; exploitation of the oceans beyond national jurisdiction; exploration of outer space; genetic manipulation of human physiology; and psycho-chemical influences on human personality. In trying to cope with these and other problems of the technoscientific age, the law is increasingly compelled to take cognizance of scientific evidence. Even the voice of the people cannot make a scientific truth out of a political falsehood.

Means are needed to speed up the adaptation of law to conditions of the technoscientific age. Law revision commissions in several of the American state governments assist the technical updating of the law, but they are rarely, if ever, equipped to deal with the larger dimensions of the problem of technoscientific change. Some instrumentality for rapprochement of science and law is needed, not only in the United States, but in all technoscientifically advanced countries. Not only domestic national law but also international law must be clarified, revised, and expanded to guide new supra- or transnational enterprises. A deficiency of adequate legal concepts is today a deterring factor in the establishment of transnational agencies for management of the oceans and polar regions, and for the exploration of outer space. Thus science transforms the character of the law and forces it to expand its dimensions.

TOPIC 14 SCIENCE, HUMAN RIGHTS, AND THE ROLE OF THE LAW

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TOPIC 14 SCIENCE, HUMAN RIGHTS, AND THE ROLE OF LAW

TOPICAL OUTLINE	REFERENCE KEY
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LEADING QUESTIONS

1. What has been the net effect of science on belief in human rights--positive, negative, or neutral? What is the evidence?

2. Have efforts to discover a natural (or scientific) basis for positive law been naive, misguided, or premature? Have the difficulties been informational, perceptual, or institutional?

3. What are the legal and moral implications of advances in medical technology which make it possible to keep alive for considerable periods patients who may have suffered irreparable brain damage?

4. If we postulate a situation in which a "scientific truth" and a "political truth" are in conflict in society, which truth should prevail? In what respects are the assumptions of science and democracy mutually reinforcing? --potentially antagonistic?

5. With the availability and prospective application of new instruments of control over society, how can traditional concepts of freedom under law have meaning?

6. How far is it possible or desirable for government to control the use of electronic or other "spying" devices? Is privacy a human right? What is the evidence?

7. What "new rights" have been made feasible by science and what traditional rights have been modified or impaired? Is the very concept of "human rights" inconsistent with a scientific outlook?

8. What basic differences in attitudes concerning the economic and social roles of scientific and technological innovation are reflected in U.S. and U.S.S.R. patent laws?

9. To what extent must the scientist bear moral responsibility for the uses made of his innovation by society (in his own country or in a foreign country)? Could or should scientists band together in refusal to work in certain harmful areas of knowledge (e.g., nuclear weapons, germ warfare)?

10. What evidence might be cited for present or approaching changes in influence by scientific knowledge in the following areas:
    a. Property rights
    b. Sociopathic behavior
    c. Public health (e.g., sanitation, innoculation, flouridation)
    d. Publication, printing, broadcasting, etc.
    e. Medical, psychological, and social experimentation
    f. Domestic relations

TOPIC 15 GOVERNING THE TECHNOSCIENTIFIC SUPERCULTURE

One effect of science and technology upon modern society has been to create a new level of assumptions, values, methods, and information that transcends national and traditional cultural boundary lines. This level of awareness (or of knowledge) corresponds in some respects to the phenomenon that V. I. Vernadsky and Pierre Teilhard de Chardin called the "noösphere". Perhaps it is more because it includes material objects and social institutions as well as inanimate ideas. It is here described as the technoscientific superculture, not because it is necessarily superior to traditional cultures, but because it is a new cultural level overlaying geographically localized historical societies.

As noted under Topic 14 (Science, Human Rights, and the Role of Law), the inability of legal and judicial institutions to adjust to changing conditions is one of the major policy problems of the technoscientific age. In traditional societies where law could be relatively static, government could be largely a process of adjudication. In a technoscientific society, however, the tasks of government are increasingly managerial. The type of law which best serves as a foundation for public management is not always the same as that intended as a basis for the judgment of courts. A new structure of public accountability is required if society is to benefit fully from science and technology, and is to avoid both the tyranny of the technocrat and frustration from obsolete legal strictures.

The challenge of the technoscientific superculture to management is at least three-fold. The primary challenge is conceptual. It is to identify the needs of a viable industrial society, and the means to meet them, without impairing the ecological basis of that society or of human welfare generally. In the second place, the task of management is one of institutional development. The advancement of science and technology has resulted, often indirectly, in problems new in kind or magnitude for which traditional machinery of government does not suffice. Exploration of outer space has been one of these, and the control of environmental pollution and the universal extension of health care are policy areas that have yet to find adequate institutional expression. The third challenge is one of human development. To manage the forces liberated through science requires public officials and administrators with qualities rarely evident in the past. The stakes for success and failure in the superculture are too high to leave the quality of leadership in policy and management to chance. Ways must be found to provide society with leadership competence in the right places at the right times. This is largely a new task of higher education in which government, industry, the professions, and the universities must collaborate. Concomitant with this task is the upgrading of public understanding of science and technology, so that true reciprocity and responsibility can prevail between the roles of scientist and citizen and between both of these and the leadership in policy and management of the technoscientific superculture.

TOPIC 15 GOVERNING THE TECHNOSCIENTIFIC SUPERCULTURE

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TOPIC 15 GOVERNING THE TECHNOSCIENTIFIC SUPERCULTURE

TOPICAL OUTLINE	REFERENCE KEY
I. Demands of the New Science and Technology upon Management	3, 97, 111, 150, 159, 172, 174, 206, 239
A. Information: high-level demand for extensive, accurate, and timely data	6, 68, 105, 151, 201
B. Interlocution: intermediary communication among specialists and diverse interest groups	87, 95, 155, 156, 198
C. Prescience: ability to detect trends and to predict developments (Cf. Topic 13)	13, 17, 203
D. Adaptability: capacity to respond to rapid changes in technology and the environment	3, 27
E. Versatility: tolerance for complexity and multi-focused problem-solving	87
II. Impact of Science and Technology upon Managerial Concepts and Practices	4, 46, 89, 150, 174, 184, 225, 231, 259, 261, 266, 281, 286, 294
A. "Scientific management"	114, 123, 197, 227, 246, 258
1. Frederick W. Taylor and the search for the "one best way"	171, 291
2. Efforts to develop a rational, prescriptive, "scientific" practice of management	46, 47, 132
3. Internationalization of the scientific management movement	88, 92, 96, 121, 126, 131, 145, 274, 303
B. Industrial psychology and organizational behavior	40, 52, 143

1. The Hawthorne experiments	56, 276
2. Human relations and group dynamics research	197, 245
3. Growth of personnel administration in government and industry	245, 276
C. Factors affecting the creativity of scientists and engineers	24, 35, 50, 51, 62, 75, 77, 93, 95, 117, 127, 130, 141, 144, 149, 155, 156, 162, 166, 196, 250, 257, 267, 270, 277
1. Organizational structure	3, 10, 41, 61, 115,
2. Intellectual capability	39, 109, 160
3. Age and physical condition	
4. Rewards and recognition	8, 21, 28, 29, 33, 69, 70, 104, 136, 139
5. Popularity of area of work	48
6. Personal motivation	22, 39, 54, 67, 95, 140
7. Pressure to be productive	64, 138
8. Freedom to do work of own interest	124
9. Patent policy and contract restrictions	23, 218, 296
10. Exceptional psychological factors	15, 81, 118
D. Operations research and "management science"	44, 91, 94, 119, 193, 195, 215, 246, 254, 268, 278, 282, 292
1. Efforts to cope with organizational size and complexity through quantitative analysis and mathematics	52, 158, 212
2. Objective: to study the management process scientifically, rather than to attempt to make the practice of management a science	36, 101
3. Product: a new kind of specialist--the systems analyst, advisory or auxiliary to traditional management	59, 65, 79, 122, 168

E. Scientific concepts injected into management theory and practice	11, 45, 100, 102, 125, 143, 148
1. Systems theory influence on organizational structure and managerial control	63, 83, 108, 129, 181, 186, 191, 246, 249, 253
2. Probability theory influence on actuarial forecasting and organizational decision-making	119, 223
3. Communications theories influence on management-employee information practices and communication with organizational clientele and the public	180, 272
4. Psychology of personality influences on selection and placement of personnel and use of standardized tests and performance ratings	31, 32, 64, 223
III. Science-Derived Tools of Managerial Operations, Analysis, and Decision-Making	27, 157, 231, 233, 284
A. Hardware--examples	43, 132, 222
1. Office machines	
2. Communications media	241, 272
3. Computers	6, 16, 76, 78, 105, 113, 161, 209, 283
B. Software--examples	91, 182, 238
1. Records management systems	241
2. Personnel management systems	135
3. Accounting and inventory systems	103, 151
4. Budget, planning, programming systems	12, 103, 264, 300
5. Operations control systems (e.g., PERT)	83, 252, 262
6. Models and simulation	1, 55, 92, 128, 194, 243, 292
IV. Educational Implications for Management in a Technoscientific Superculture	26, 82, 147, 203, 280, 304

A. Necessity for a continuous process of education	71, 72, 97
1. Omnipresent threat of obsolescence	
2. Preparatory education must be fundamental, not ephemeral	
3. Periodic up-grading through "executive development" experiences is essential	
B. Cultural orientation required for effective managerial leadership	5, 30, 235
1. Manager must be able to operate in two cultures: traditional and technoscientific	13, 234
2. Educational experience ought, therefore, to provide appreciation of the full range of the cultural environment: humanistic, scientific, technical, political	131
C. Better means are needed to increase the probability of managerial positions being filled by persons with qualities best suited to the demands of the new technoscientific society	26, 82
1. Qualities that impel individuals into top political, administrative, and managerial positions are not necessarily those that the responsibilities of the positions require	
2. Primitive attitudes may gain exaggerated harmfulness in a highly interdependent technoscientific society	
3. A reliable psychology of motivation is greatly needed for the improvement of politics and administration and for the task of educational preparation for the management of science and technology	
V. Some Problems of Management in the Technoscientific Superculture (Micro-Administration)	189, 190, 208, 212, 217, 219, 226, 239, 248, 282, 284, 298

A. Optimization and sub-optimization	53, 155, 156, 169, 200, 251
1. Ascertaining point of satisfactory accomplishment (Simon's "satisfycing")	
2. Calculation of costs and benefits at alternative levels of accomplishment and through alternative methods	12, 58, 103, 134, 170
3. Investigation of possible inadvertent and indirect consequences	42, 213, 214
a. Recourse to systems analysis	99, 111, 137, 142, 179, 181, 191, 192, 268, 269, 278, 297
b. Use of simulation	55, 85, 128
B. Organization of complex operations within a critical time dimension (initially exemplified in military operations and now extended to industrial production, outer-space exploration, and biomedical technology)	52, 79, 86, 165, 249, 255
1. Monolithic versus federalized (contractual organization)	216
2. Combination of authority and specialized competence: functional, program, and project management	57, 84, 177, 238
3. Control systems: timing, coordination, quality of performance	4, 112
4. Stand-by auxiliary facilities	120
5. Organizational tasks of simplification, refinement, and phase-out	120
C. Organizational cybernetics: steering the organization through its task environment	9, 83, 128, 202, 262
1. Surveillance and mapping of the task environment	
2. Interpretation of the significance of environmental interactions	
3. Development of feed-back and early warning systems and automatic response mechanisms	

VI. Policy Problems of Managing the Technoscientific Superculture (Macro-Administration)	18, 19, 74, 85, 86, 175, 183, 216, 304
A. Ascertaining the goals and priorities toward which the resources of the technoscientific society should be directed (Cf. Topics 11 and 12)	26, 66, 176, 271, 289, 301
B. Control of technology in the public interest (Cf. Topic 14)	7, 38, 89, 90, 188, 256
1. Reformulation of the public interest in the results of technological change	207, 272
2. Instrumental means for control of technological change	150, 269, 289
C. Resolving the conflict inherent in differences between the autonomy of technoscientific institutions and the values of democratic self-government	207, 216
1. Query: are there inherent conflicts between science, technology, and democracy, or only between certain concepts and interpretations?	7, 187
2. Examination of the rationale for prevailing organization for science and technology	121, 216, 271
3. Development of an integrative concept of social control to assist the harmonization of scientfiic truth, technological advantage, and democratic responsibility	17, 146
4. Necessity for administrative leadership in the integrative task	7, 26, 30, 106, 289

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LEADING QUESTIONS

1. How would you distinguish between the administration of scientific and technological activities within the government and the administration of general policies affecting the applications of science and technology?

2. How much of a nation's economic effort should be channeled into the advancement of science? By what criteria should allocations be made among sciences?

3. What is meant by the "bureaucratization" of science? Is this an inevitable concomitant of big science?

4. Should the administration of science be restricted to "scientists"? Can an "administrator" without science credentials administer science policy? What has been the experience in government? In industry? In hospitals? In universities?

5. What policy and operational problems arise from the interrelationships among universities, industrial establishments, professional groups, and various government agencies in the public administration of science? Are these relationships consistent with traditional concepts of governmental accountability and distinctions between public and private interests?

6. How have science and technology influenced the character of the administrative process generally? What are specific illustrations of technology in administration?

7. What aspects of administration have not yet been influenced significantly by science? In what respects could science most greatly benefit administration today? How does "management science" attempt to improve management?

8. Is "technocracy" primarily a consequence of the ambition or self-confidence of science professionals and engineers, or of popular ignorance, folly, or indifference? Are there other factors?

9. What should be the content of education for the administration of science policy, and how, when, and where should it be acquired? Is the same true for applied science?

10. Must the reconciliation of scientific and democratic values be undertaken in large measure through the administrative process, broadly construed? Would it not be enough to resolve differences through conferences and colloquia, or through public education toward a more adequate understanding of science?